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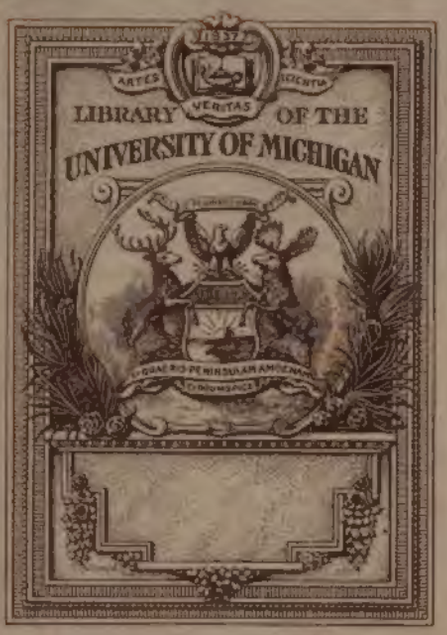

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GEOLOGICAL SURVEY OF KENTUCKY.

N. S. SHALER, DIRECTOR.

REPORTS OF PROGRESS.

VOLUME IV. NEW SERIES.

STEREOTYPED FOR THE SURVEY
BY MAJOR, JOHNSTON & BARRETT.
YEOMAN PRESS, FRANKFORT, KENTUCKY.
1878.

INTRODUCTORY LETTER.

To His Excellency, JAMES B. MCCREARY,
Governor of Kentucky:

SIR: I have the honor to submit herewith the fourth volume (new series) of the Reports of the Geological and other Surveys of the Commonwealth. All necessary explanations concerning the same will be found in the introduction preceding the Reports.

Very respectfully,
Your obedient servant,
N. S. SHALER,
Director of the Surveys.

NOVEMBER 15, 1877.

150958

INTRODUCTION TO THE FOURTH VOLUME.

The twelve reports of this volume concern a part of the work of the Survey which was done in the years 1875–'6. The various subjects have all a more or less intimate relation to reports contained in the earlier volumes of the Survey. In order to facilitate reference to these earlier reports, I shall now proceed to consider the subject-matter of the several sections of this volume, making in each case reference to the other work done by the Survey on the same subjects. In this task I must limit myself to the more important points of relation between these several contributions, otherwise this introduction would swell to the proportions of a full volume in itself. It is my intention to have the forthcoming seventh volume of these reports given up to a careful series of indexes, intended to guide the inquirer to all the various publications of the Survey. This index, which will take account of the publications of the first as well as of the second Survey of the Commonwealth, will bring together the information contained in twelve or more volumes of Reports and Memoirs. It cannot, however, be published before 1879, and its appearance will depend upon the continuance of the appropriations for the Survey. For immediate purposes it is, therefore, advisable to give this introduction, showing the general relation of these papers to those which have gone before.

The report of Dr. Robert Peter is, as will be seen, the sixth since the beginning of the Survey, and the second of the new series. Although each chemical analysis has a certain completeness in itself, it will be found that each of these analyses is intimately connected with work done before. Of the hundreds given in this report, it may be said with safety that they each form part of a scheme of a chemical study of the Commonwealth, and must be considered in connection with

what has been done before on the same class of substances. If the future of the Survey allows, it is my intention to have these various reports from the chemical laboratory brought into a closer relation with each other, by republication in a single volume. There can be no doubt that they contain the largest amount of chemical information that has ever been brought together concerning an equal area in this or any other country. A reference to the indexes of the several volumes will be the only way at present open for bringing the contents of these several reports into relation with each other.

The report on the geology of Menifee county, by A. R. Crandall, is the first of a series of county reports which I hope may be continued until all of the counties have received a similar treatment. As this county is well placed as a key to a considerable district, it has required a more voluminous description than it will, in all cases, be necessary to give to the other counties of the Commonwealth. For further information on this district, the reader may consult, with advantage, the succeeding report, by Mr. P. N. Moore, concerning the geology of the Red River region, which immediately adjoins the Menifee district. It will be well for the reader who is seeking information concerning the iron ores of this county to compare also the other reports of Mr. Moore on the iron resources of the Commonwealth, contained in the first and second volumes of this series. Mr. Moore now has in preparation a report on the washing and coking of coals for furnace purposes, which I hope may be published in the latter part of the sixth volume of this series of reports. The reader will find therein important considerations concerning the use of our more sulphurous coals in iron furnaces. The most important question in this Slate Creek district concerns the use of the local and abundant ores with the coals of the district in their raw or coked state for fuel. I am disposed to think that the coals of this district may need either washing or coking to be of value for furnace use; though I should say that my colleague, Dr.

Peter, is inclined to think that they may work well in a raw state.

The report of Mr. Crandall on the geology of the region adjacent to the line of the Lexington and Big Sandy Railroad will also be of value to the student of this region. This will be found in the second volume.

The report on the iron manufacture of the Kentucky Red River iron region, by Assistant P. N. Moore, is of a rather special nature, and is especially designed to aid in the revival of the important iron industries of this district. The reports, by the same gentleman, on the iron industries of the Kentucky division of the Hanging Rock district, in volume 1st, may also be consulted with advantage.

The report on the geology of the region adjacent to the Kentucky and Virginia State line, from the Cumberland Gap to the Chatterawha or Big Sandy river, by P. N. Moore, gives the results of a reconnoissance along a part of the border line of the State that had never been carefully observed by any of the officers of the Survey. In 1874 I made a journey from the mouth of Chatterawha or Big Sandy to the neighborhood of Cumberland Gap, but followed the valley of the main fork of the Chatterawha to near Pound Gap, and then descended the Poor Fork of the Upper Cumberland. Mr. Moore's reconnoissance gives some light upon the geology of a district several miles to the west of the line traversed by me. Further information on this district will be found in the last report in this volume, and also in my own reports on the work of the Survey for 1875 and 1876, in the third volume of this series.

The report on the iron ores of the vicinity of Cumberland Gap, by Mr. Moore, concerns a set of valuable iron ores, the actual outcrop of which is beyond the State line, within the limits of Tennessee and Virginia, but which not only extend beneath Kentucky, but which will require the coals of Kentucky for their smelting, and may therefore be regarded as of value to our Commonwealth. These iron ores are of the same age as those found at the Preston ore banks, near Mt. Sterling, and are identical with those from which are derived

the most profitable sources of supply in the East Tennessee furnaces. Some general considerations concerning these ores will be found in the reports contained in the third volume of this series.

The sixth report, on the geology of a section from near Campton, in Wolfe county, to near the mouth of Troublesome creek, Breathitt county, by Mr. Moore, was designed to aid in the extension of our as yet limited knowledge of the region adjacent to the head waters of the Kentucky river. Although giving only the geology of the district immediately adjacent to the line of the section, this report will serve to make it clear that this region has a full share of workable coals, some of remarkable purity and great value. Further information concerning the same district may be found in the report of Mr. Crandall on Menifee county, which lies on the eastern border of this district.

The seventh report, that entitled a report of examinations made along the line of the north and south running railways of Western Kentucky, by Charles J. Norwood, concerns a district which has been made the seat of Mr. Norwood's labors for several years. This report, as well as the others from the hands of Mr. Norwood, are essays towards an understanding of this very difficult field. Owing to the very hidden nature of the geology of this district, and to the considerable disturbances concealed beneath its seemingly simple surface, it requires a great deal of patience to unravel its structure. Some years yet must pass before we can hope to have all its structural peculiarities well worked out. Mr. Norwood's other reports concerning this portion of the State may be consulted to advantage. They will be found under the title, "Report on the Geology of the Region adjacent to the Louisville, Paducah and Southwestern Railway," volume 1st, new series, and his report on the geology of Ohio county, now in press, in the fifth volume of this series.

The eighth report, entitled "A Report of a Reconnoissance of a part of the Breckinridge Cannel Coal District," by C. J. Norwood, is a special report, drawn up at the request of the

owners of the important mines of that name, with a view of providing information for those who might desire to make this district again accessible to markets. There is no other cannel coal area in this country so accessible to transportation as this. I am satisfied, that from it coal can be sent, at present prices, with profit, to the great markets of the Atlantic coast, by way of New Orleans. For a good part of the year vessels drawing ten feet of water can be loaded at the old wharves of the mines and taken, by way of New Orleans, to the sea. The charge for towage of vessels mounting the stream will not exceed one dollar per ton, or the cost of one hundred miles of carriage on the cheapest American railways. The actual cost of carriage to New York ought not to exceed six dollars per ton, while the *Ince Hall* cannel, in no way superior, is now bringing fifteen dollars in that and the other Eastern markets, where there is a large demand for domestic use, and for enriching coal gas. Steam colliers, carrying about eight hundred tons, and built to draw no more than nine feet when loaded, would be best suited to this work. They could expect to make several round trips between November 1st and June 1st, when rarely a month passes without sufficient water being found in the Ohio and Mississippi rivers to make the journey quite practicable. Or, if desired, the coal could be perhaps quite as cheaply transhipped at New Orleans from the ordinary flat-boats, upon sea-going vessels. For this handling the peculiarly solid character of this cannel coal makes it eminently fit, as not one per cent. of the whole would be lost in the transfer. I would also suggest, that at the present price of similar coals in Liverpool, where they bring from ten to twelve dollars per ton, it would perhaps be advantageous to store a part of the contents of cotton ships with our American cannels. I understand that cotton ships require a small amount of ballast material to keep the center of gravity lower than it would be brought by a light-weighted load, such as cotton or hemp or tobacco.

Part nine of the volume contains the fourth report on Kentucky forests, and the second by Mr. L. H. DeFriese. The

first report by Assistant Crandall and myself will be found in the first volume of this series. In the same volume will be found the report on the timber of Edmonson county, by Assistant Hussey. The second volume contains a report on the timbers of the Hancock county district, by Mr. DeFriese. The third volume contains several references to the timber areas of the State, and a very valuable extract from the great work of Hon. George P. Marsh, entitled "The Earth as Modified by Human Action." This extract gives, in brief space, the most important facts concerning the effect of forests upon rivers and climate. Still other reports of Mr. DeFriese are now in press, or in readiness therefor. Two of these, the one on the timber of the Tradewater district, another on the timber resources of the Purchase district, are now printing in the fifth volume. An extensive report on the timber exhibits at the Centennial Exhibition is now in an advanced state of preparation, and will appear in the sixth volume of the new series. It is my hope that these studies of our admirable forests may be carried forward to completion. No other such statistical survey of the forests of a country has ever, so far as my knowledge goes, been undertaken. I am satisfied that it will prove at once a source of honor and of profit to the Commonwealth. The present report of Assistant DeFriese calls attention to the valuable timber district of the Upper Cumberland, which has remained almost untouched by the wood man down to the present day.

The tenth report, by Mr. P. N. Moore, on the geology of Hancock county, is one of the county reports, similar to that on Menifee, which the Director is required by law to have made concerning each of the political units of the Commonwealth. Among the unfinished work of the Survey, suspended by the lack of means, are similar reports concerning twenty or more counties in different sections of the State. These reports are designed to be published separately, and in this shape will contain full references to other sources of information concerning the area in question, and a special map of the county compiled from the records of the Survey.

The eleventh report, on the geology of the region adjacent to the eastern border of the western coal field, from the Louisville, Paducah and Southwestern Railway to the Ohio river, by P. N. Moore, gives an account of the continuation of the work of running the outline of the western coal field, which was begun soon after the re-institution of the Survey. The second volume of these reports gave the results of the work in the district south of that now treated of by Mr. Moore. The western face of the field is now in the hands of Assistant Norwood, and a report on the district between the Tradewater and the Cumberland rivers, north of the Paducah Railway, is now in preparation for the press, and may be expected in the fifth volume. The work of determining the precise limits of the western coal field will then be extended along its southern face.

The twelfth and final report of this volume—that on the geology of portions of the upper Cumberland River Valley in Bell and Harlan counties, by A. R. Crandall and P. N. Moore—gives a brief and somewhat anticipatory account of studies made under my direction in this district, with a view to laying the foundations for more detailed work in the future. As will be seen from the sections that accompany this report, the region in question has been subjected to the violent action of mountain-building forces, which have greatly disturbed the natural attitudes of the rocks. These disturbances will make it necessary to narrowly examine all the ground in this district before venturing upon final reports as to its geology.

It seeming probable that several of the reports of this volume would require extensive additions in subsequent editions, the number of pages has been somewhat restricted, with a view to allowing such increase without unduly swelling its bulk.

N. S. SHALER.

OFFICERS OF KENTUCKY GEOLOGICAL SURVEY

DURING THE TIME OF PREPARATION OF THE REPORTS CONTAINED IN THIS VOLUME, IN THE ORDER OF THEIR APPOINTMENTS.

NATHANIEL SOUTHGATE SHALER, *Director and Principal Geologist.*
ROBERT PETER, *Principal Chemist.*
ALBERT ROGERS CRANDALL, *First Assistant in Geology.*
PHILIP NORTH MOORE, *Assistant in Geology*
CHARLES SCHENK, *Assistant in Topography.*
CHARLES JOSEPH NORWOOD, *Assistant in Geology.*
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LEOPOLD TROUVELOT, *Artist of the Survey.*
JOSEPH BERNARD HOEING, *Assistant in Topography.*
JOHN BELKNAP MARCOU, *Aid.*

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GEOLOGICAL SURVEY OF KENTUCKY.

N. S. SHALER, DIRECTOR.

CHEMICAL REPORT

OF THE

SOILS, COALS, ORES, IRON FURNACE PRODUCTS, CLAYS, MARLS, MINERAL WATERS, ROCKS, &C.,

OF KENTUCKY,

BY ROBERT PETER, M. D., ETC., ETC.,

CHEMIST TO THE KENTUCKY GEOLOGICAL SURVEY.

ASSISTED BY

JOHN H. TALBUTT, S. B., CHEMICAL ASSISTANT.

SECOND CHEMICAL REPORT IN THE NEW SERIES AND THE SIXTH SINCE THE BEGINNING OF THE SURVEY.

PART I. VOL. IV. SECOND SERIES.

I & 2

INTRODUCTORY LETTER.

CHEMICAL LABORATORY OF THE
KENTUCKY STATE GEOLOGICAL SURVEY,
LEXINGTON, February, 1877.

Professor N. S. SHALER, *Chief Geologist, &c.:*

DEAR SIR: I have the pleasure to report the results of the chemical work performed by myself and Mr. Talbutt, for the State Geological Survey, during the past year, or since the preparation of the last report nearly up to the present date.

Very respectfully,

ROBERT PETER.

CHEMICAL REPORT OF THE SOILS, COALS, ORES, IRON FURNACE PRODUCTS, CLAYS, MARLS, MINERAL WATERS, ROCKS, &c., OF KENTUCKY, BY ROBERT PETER, M. D., ETC.

The chemical analyses of eighty-three *soils*, from twelve counties of the State, are given in the following detailed report. The limits of the variations of their several essential ingredients are shown in the following table, viz:

	Pr cent.	No	County.	Per cent.	No.	County.
Organic and volatile matters vary from . . .	11.565	in 1684	in Bell	to 1.052	in 19036	in Muhlenb'rg.
Alumina and iron and manganese oxides vary from	19 921	in 1783	in Fayette . .	to 2 815	in 1692	in Bell.
Lime carbonate varies from	1 145	in 1781	in Fayette . .	a trace.	in 1871	in Lewis.
Magnesia varies from.	394	in 1781	in Fayette .	to .011	in 1853	in Laurel.
Phosphoric acid varies from.	540	in 1780	in Fayette . .	to 061	in several	al.
Potash varies from	755	in 1783	in Fayette .	to 068	in 1680	in Bell.
Soda varies from	477	in 19030	in Muhlenburg	to traces	in several	al
Sand and insoluble silicates vary from . . .	72 540	in 1783	in Fayette . .	to 95 115	in 1683	in Bell
Water expelled at 380° F. varies from . . .	2 515	in 1696	in Bell .	to .035	in 1684	in Bell
Water expelled at 212° F. varies from	3 525	in 1783	in Fayette . .	to 435	in 18526	in Knox.
Potash in the insoluble silicates varies from .	2 640	in 1696	in Bell . .	to .399	in 18526	in Knox.
Soda in the insoluble silicates varies from . .	1 044	in 1728	in Christian to	traces in	several	

This table of extremes of composition shows wider limits than that of volume I, and may be supposed to exhibit the relative chemical composition of very good and very poor soils. The rich soil being characterized by larger proportions of organic and volatile matters (within certain limits), causing the soil to absorb and retain much hygroscopic moisture (expelled at 212° F.); larger relative quantities of alumina, &c., &c., which hold more water, &c., expelled at 380° F.; but especially being more rich in the available alkalies, potash and soda (particularly potash); by containing more phosphoric acid, lime, &c., and having less sand and insoluble silicates. The poor soil generally contains a larger quantity of sand and insoluble silicates and smaller proportions of the other named ingredients. Exceptions occur to these general statements, of course; for great excess of lime or magnesia carbonates,

of organic matters, or of clay, may make a poor soil; or, on the other hand, the absence of any single essential element in it may render unavailable normal proportions of all the others. The study of the soil in relation to its productiveness presents, indeed, a complex problem; many conditions, both physical and chemical, enter into it, all equally important. Even the relative state of division, whether fine or coarse, of two soils otherwise presenting similar chemical, physical, and atmospheric conditions, is found greatly to influence its fertility.

Another varying condition is the influence of water upon the soil, which, in the valley, may bring fertilizing ingredients to the soil from the higher grounds by deposit of suspended mud left by the overflowing fluid, or may carry dissolved elements of plant food into its interior by gradual infiltration. On the other hand the flood, on the higher slopes, not only carries off to the lower levels the richer and finer solid materials, but, by a continued leaching process, may actually dissolve and remove the alkalies, lime, magnesia, phosphates, and organic matters, and even gradually decompose the insoluble silicates and carry off the store of alkalies naturally contained in some of them. The examination of some of the soils of the mountain region seemed to show that underground drainage, through a measurably open subsoil, had thus acted on the silicates contained in them.

In many cases the subsoil in the samples examined was richer in the mineral elements of fertility than the surface soil, and in some few cases it seemed to have had a different origin. The influence of the subsoil, when more or less mixed with the upper soil in the processes of cultivation, was measurably observable in studying the gradual exhaustion produced by cropping. In some cases seemingly making the soil of the old field fully as rich as the virgin soil, supposing both originally to have been similar in composition, which is not always true. The comparison of the old cultivated soil with the virgin soil of the immediate vicinity does not, therefore, in all cases, show an apparent reduction of the elements of fertility in the former; yet, the fact is demonstrated, in a large propor-

tion of cases, where the soil is uniform in the region and care has been taken in the selection of the samples. Superficial impurities, which might greatly interfere with the results, are easily to be avoided in the collection of the soils in most cases.

But the subsoil, although quite rich in potash, soda, phosphates, and other mineral fertilizers, does not always improve the immediate fertility of the soil when brought up to the surface in too large quantity at one time. Indeed gardeners find, generally, that it reduces the fertility of the surface unless it is liberally mixed with organic manures. Hence, while they may loosen the earth to a considerable depth, by a process of *subsoiling*, to favor drainage, the penetration of the atmospheric gases and the free spreading of the roots of their vegetables, they are generally careful not to *trench* the soil so as to throw much of the heavy subsoil upon the surface. Of course subsoils vary in composition; but the subsoils of this region are usually quite rich in potash, soda, and phosphates, held in firm combination, however, in the silicates which are insoluble in the ordinary acids; they contain more of the materials of clay—alumina, iron oxide, &c.—than the surface soil generally, and but a small quantity of organic and volatile matters.

As the organic compounds of the soil are greatly instrumental in bringing the mineral elements of plant food into a soluble or available condition, and as they even act on the insoluble silicates, to set free and make soluble their constituent alkalies and phosphates, &c., the measurable absence of the organic matters from the heavy subsoil may have much to do with its inertness as compared with its chemical composition.

The extensive study which has been made in this laboratory of the insoluble silicates of our soils, during the past year, has thrown much light on this subject, as well as on the probable origin of some of our soils. All of the soils examined were found to have a notable quantity of alkalies in the silicious residue left after a ten,or twelve days' digestion in chlorohydric acid of the density of 1.1, and, as may be seen by refer-

ence to the table of extremes of composition given above, this quantity varies from 2.640 per cent. of potash down to 0.399 per cent., which was the smallest proportion found in any, and which, as is universally the case, is much greater than the amount removed from the soil by the action of chlorohydric or nitric acid.

The silicious residue of our Kentucky soils, left after prolonged digestion in the acids, is generally in such a fine state of division that all or most of it will readily pass through fine bolting-cloth. Hence our best Kentucky soil has been popularly said to have no sand in it. Indeed, in the "Blue Grass Region," so-called—the most fertile part of the State—sand is so scarce that it usually must be hauled from the river beds at some distance, and its cost to the builder is quite considerable. But a large proportion of the very fine silicious residue of our soils is really very fine quartzose sand, some grains being clear and colorless, some milky or colored, and only a few, of the same character, separable by the bolting-cloth from some of the soils, are of a somewhat larger size, indicating the fact that our soils, or the rocks from the disintegration of which they are derived, have been deposited under comparatively quiet waters, possibly of a deep sea at a distance from its shores.

But, mixed with the purely silicious grains is quite a considerable quantity of grains of *silicates*, containing the alkalies in considerable proportions, doubtless of the nature of the felspar and mica of the granitic rocks and other minerals analogous in chemical composition, holding in reserve a great treasure of these important elements of organic nourishment, the alkalies.

When we consider the wide diffusion of these finely divided silicates—for it is probable they enter into the constitution of all the soils of the world—we may well be astonished at the vast extent of rock disintegration which was necessary to their production, and admire this wonderful provision for maintaining the productiveness of the soil.

As regards the proportion of *phosphates* contained in these insoluble silicates, it is the design of the writer to institute an investigation, as occasion may favor, during the progress of the Survey.

It has been conclusively established that *mineral* fertilizers alone will not suffice to render soil productive. The greater proportion of vegetable and animal bodies is made up of the so-called *atmospheric elements*, viz: carbon, hydrogen, oxygen, and nitrogen; and the latter element, although entering into their composition in much smaller proportions than the other three, has most attracted the attention of vegetable physiologists and agriculturalists; mainly for the reason, that while the carbon is readily appropriated by the plant, in the decomposition of carbonic acid under the influence of the sun's light—this acid being never absent from the soil or the atmosphere—and water, always present, yields the necessary hydrogen and oxygen, nitrogen cannot, as a general rule, with some exceptions, be directly assimilated from the atmospheric gases by the growing vegetable. With the exception of plants of the clover or pea family, and a few others, all growing vegetables must be supplied with this essential element, nitrogen, in some form of compound, they not seeming generally to be endowed with the force requisite to coerce into the liquid or solid state this gas, which has withstood all the efforts of man, by the use of immense pressure and intense cold, to condense it even into the liquid form.

Under ordinary circumstances of natural vegetable growth, nitrogen is presented to the plant, sometimes in the form of ammonia (composed of nitrogen and hydrogen), or of some of its compounds, resulting from the decomposition of animal bodies and products; sometimes in that of nitrates or analogous compounds, which originate in the union of nitrogen and oxygen and some base; all of which nitrogenous compounds are easily soluble in water, and thus readily enter the vegetable tissues. But the ordinary natural supply of these compounds is limited, and hence, when the soil is to be stimulated to its highest degree of productiveness, and its fertility made

continuous, the cultivator necessarily resorts to the admixture of nitrogenous compounds of some sort with his fertilizers. The nitrogenous organic compounds of both animals and plants are always associated with phosphates; and it is believed, that while potash is absolutely necessary in the growing vegetable for the production and transfer of its non-nitrogenous constituents, nitrogenous compounds and phosphates are also mutually dependent—all being equally indispensable. So that the agricultural chemists of the Liebig school, who contend for the exclusive importance of the mineral elements of fertility, and those of the French and English schools, who see no value in manures outside of the nitrogen compounds, are equally too exclusive, and equally in fault.

These questions have long been of vital interest in the older and more thickly populated countries, while in our comparatively new continent the virgin soil still bountifully responds to the labor of the farmer without the aid of artificial fertilizers, and with but little evidence of exhaustion. But here, as everywhere, except where the soil is continually renewed by exceptional and local causes, such as the existence of an unusually rich and readily decomposable sub-stratum, or the periodical fertilizing overflow of rivers, the continued demands of the farmer upon the land inevitably reduces its productiveness—an effect which is increased as population enlarges. And it is even now the fact that, over a large portion of our State and country, profitable farming without the aid of manures is practically at an end. The future of our husbandry will be mainly the application of fertilizers to the soil, as a vehicle of production, by the aid of capital, skill, and industry; which will be the more profitable as the population becomes more dense, and the home market is enlarged by the increase amongst us of other industrial occupations, more especially of the manufactures.

Kentucky is eminently endowed by nature for the support of extensive and most important manufactures. Her immense natural resources in coal, iron ores, clays, limestones, salt, &c., &c.—materials which are essential to almost all the

arts of civilization, and give employment to more individuals than any other natural products, those of the field, perhaps, excepted—only await development to make her one of the most powerful Commonwealths of the world. The great wealth and power of Great Britain rest on her coal and iron fields mainly.

During the past year, proximate analyses have been made, in this laboratory, of one hundred and forty-seven several samples of *Kentucky coals*, in addition to those reported in previous volumes of the reports. As might have been expected, these exhibit a considerable variety in their composition, as may be seen by examining the table at the end of this chemical report.

The general average of ash and sulphur in the coals examined this year doubtless falls somewhat below that of the samples examined in the previous year; but, as might be expected, very great differences are to be observed among them. Thus the limits of the ash per centage extend from 2.60 per cent., in Nos. 1908 and 1810, from Ohio county, to 34.72 per cent., in No. 1914, from Ohio county.

The great proportion of the ash of No. 1914 is exceptional, however, and although this coal is called a cannel coal by some, it doubtless should be denominated a bituminous shale. Indeed, where the earthy matters exceed twenty per cent. of the material, the name coal is not as appropriate as the latter term, although the mineral may yet be made quite useful for fuel, or possibly for distillation, in the vicinity of its bed.

The limits of total sulphur in these coals examined this year are from 0.530 per cent., in the cannel coal, No. 1966, from Wolfe county, to 7.959 per cent., in No. 1923, from Ohio county.

A remarkable fact in relation to this latter coal is, that while the sulphur per centage is nearly eight the ash per centage is only a little above twelve, indicating that much of this combustible substance is either in the free state or in some form of organic compound in the coal. Other coals, with a large quantity of sulphur, show the same fact, and the inference is that a considerable proportion of this sulphur may be removed

in the operation of coking the coal. Remarks on the probable condition of sulphur in coals, and on its removal, will be found in the succeeding detailed report, especially under the head of Bell county.

As was remarked in the previous volume, the coals of the eastern coal field appear to be somewhat less sulphurous, in the average, than those of the western. Recent imperfect investigations into those parts of the eastern coal field which are yet measurably unexplored, and which are beyond the usual channels of communication, have shown the existence there of coals of great value and remarkable purity, some of which, like the celebrated Indiana "Block coal," may be used in the smelting of the abundant iron ore without the preliminary process of coking.

Under the heads of Bell and Breathitt counties, the general correspondence between the specific gravity and the ash per centage was again exhibited; and it is to be noted, that while the density of the coal, as a general rule, increases with the ash per centage, the cannel coals offer a marked exception, or exhibit a ratio of their own. What the ratio is, in the different sorts of coal, cannot well be made out at present, especially because the different varieties shade into each other, and difference of age and the action of physical agencies may affect the relative density, independent of the earthy matters, as well as the various kinds of organic materials from which the coals were derived.

To illustrate more fully this correspondence between specific gravity and ash per centage, another table, viz: that of the coals from Ohio county, is appended, as follows:

Number.	Specific gravity.	Ash per centage.	Number.	Specific gravity.	Ash per centage.
1910	1.251	2.60	1907	1.336	10.30
1915	1.273	4.00	1919	1.340	8.30
1926	1.282	3.16	1927	1.348	7.72
1908	1.295	2.60	1913	1.345	9.28
1917	1.295	5.00	1920	1.356	9.94
1909	1.297	3.40	1921	1.357	8.14
1916	1.305	4.00	1922	1.380	9.34
1924	1.310	5.94	1911	1.382	9.96
1925	1.310	9.92	1918	1.384	14.20
1906	1.310	7.46	1912	1.386	9.24
1904	1.318	7.54	1929	1.411	12.50
1928	1.321	4.36	1923	1.413	12.10
1905	1.331	8.44	1914*	1.593	34.72

*A bituminous shale or impure cannel coal.

It is believed, that notwithstanding the large proportions of ash and sulphur in some of these samples of coals analyzed, the general, or average quality of the coals of the very extensive coal fields of Kentucky will compare favorably with that of the coals of any other region.

Only about twenty-four *iron ores*, of the limonite variety, and five clay iron-stones have been analyzed since the last report. These are from seven counties only, and are found to vary in their proportions of *iron* between the extremes of twenty-three and more than fifty-three per cent. of that metal. Their proportions of *phosphorus* vary from 1.60 to 0.065 per cent., the largest proportion of this injurious element having been found in the "Clinton ore," of Old Slate Furnace, of Bath county.

As is pretty well established, phosphorus is more injurious to the quality of the iron than any other ingredient of the ore, especially in causing it to be "cold-short," or, in other words, diminishing its tenacity or toughness. Silicon, in certain proportions, is also injurious in this respect; but the presence of phosphorus in the ore is more to be deprecated, because it is to be removed with more difficulty from the iron in the subsequent refining processes; silicon being easily oxidated, or burnt out with the excess of carbon and some other impurities of the pig metal, in the puddling, or even in

the Bessemer process, while phosphorus is believed to maintain more obstinately its union with the metallic iron.

The general belief was, even among modern scientific observers, that all the phosphoric acid in the iron ore, or in the flux material and fuel, used in the ordinary smelting furnace, finds its way into the reduced metal, pig iron, produced, and is held in it, in firm combination, in the form of iron phosphide. Hence, it was claimed, a phosphatic ore necessarily produces a yet more phosphatic iron, because the phosphorus, all of which is supposed to combine with the metal, is, of course, in larger proportion to the iron than to the ore, &c.

But analyses, made by the writer, of samples of iron furnace cinder or slag, published in the volumes of the first series of reports of the Kentucky Geological Survey, as well as in the present report (see Greenup county), show the presence of notable quantities of phosphoric acid in this slag, and thus lead to the conclusion that it is possible, by a proper management of the furnace and of the fluxes used, to eliminate, in this form, a considerable proportion of this injurious ingredient in the smelting of the ore. If the phosphatic iron ore, in the high furnace, be subjected to a very intense heat, in presence of the reducing gases, the phosphoric acid will be reduced to phosphorus, which will unite with the reduced iron when it melts, provided a proper basic flux material be not present to fuse with the phosphoric acid before it is deoxidated, and thus protect it from reduction. But, in the presence of such a basic flux material, it is probable that the iron of the ore, if it be reduced at a more moderate heat, and while yet unmelted, may afterwards melt at a heat not quite high enough to reduce the phosphoric acid, which then would go off in the slag.

The strong affinity which exists between alumina and phosphoric acid justifies the belief that this material, in the flux or in the ore, may be especially useful in this process of purification in the smelting furnace; when used in combination with a sufficiency of lime or other fluxing materials to make a rather fusible basic flux, and with not too high a temperature

in the reducing part of the furnace. It is well known that alumina is an essential ingredient of all clays.

It has long been known that the phosphorus of the impure iron may be removed, in great measure, by the aid of oxygen and fluxing materials; and this fact has long been practically applied in the various refining processes, in which the melted pig metal is exposed to the oxygen of the air, or to that which is separated from powdered iron or manganese oxides, or derived from common nitre or nitrate of soda. The oxygen burns out or oxidates the phosphorus (together with the other oxidable ingredients—carbon, silicon, sulphur, &c.), and the phosphoric acid which is formed unites generally with iron or manganese oxides, as phosphates, in the melted cinder. This is the theory of all the various refining processes, including that called puddling and the Bessemer process, which latter process, however, because, probably, of the want of a fluid basic flux to dissolve compounds of phosphoric acid, is not effectual in the removal of phosphorus.

Amongst the modern processes for iron purification is the patent one of Henderson, originated in England, but which seems to have been employed in this country, at the Hamburg Iron Works, Hamburg, Pennsylvania. An English pamphlet, obtained by the writer at the Centennial Exhibition, gives many interesting facts in relation to it and its results. The refining process is, to pour the melted impure pig metal on a mixture of powdered fluor-spar and titanic iron ore (ilmenite), or peroxide of manganese, &c., placed on the floor of the ordinary puddling furnace; "the furnace door being then closed, the powdered mixture fuses, and the iron is allowed to boil for about half an hour; the rabble is then worked for about ten minutes, and the metal is balled up in the usual way. The whole time occupied by one charge, with ordinary grey forge pig iron, being a little under an hour."

It is claimed, that in this time the commonest and most impure pig iron may have most of its phosphorus, sulphur, silicon, and carbon removed; and that it may be brought to a state of purity, toughness, and ductility equal to that of the

best Swedish iron. In this pamphlet this claim is corroborated by numerous chemical analyses of the pig metal and of the purified wrought iron, by Dr. Henry M. Noad, F. R. S.; Mr. Edward Riley, F. C. S.; and Mr. W. Matthiew Williams, F. C. S., as well as by many mechanical tests of the metal by Mr. David Kirkaldy.

The chemical analysis of the *slag* produced in this process throws a little light upon the theory of the depurative action of the re-agents used. (See table 19 of the pamphlet.) Some of this slag, analyzed by Mr. Edward Riley, F. C. S., gave the following results:

Silica	11.12	
Titanic acid	5.02	
Protoxide of iron	56.41	= 58.0 per cent. of *iron*.
Peroxide of iron	18.20	
Alumina	1.73	
Manganese	2.22	
Phosphoric acid	1.19	= .47 per cent. of *phosphorus*.
Sulphur	.09	
Lime	3.51	
	99.49	

The author of the process asserts that most of the phosphorus goes off in the form of vapor; but it is evident that it mostly separates in the slag, after having formed phosphoric acid by union with oxygen. No doubt the manganese oxide aided in the oxidation of the carbon, sulphur, and phosphorus of the pig iron, and the fluorine of the fluor-spar may have combined with the silicon to produce a volatile fluoride of silicon; for we see no statement of any fluorine in the analysis of the slag; but it is believed, that in the ordinary operation of puddling, the atmospheric oxygen, or that derived from a lining of powdered iron ore, &c., may remove all these, if it be carefully performed, more especially if materials be brought in contact with the boiling iron, which may readily melt into a sufficient basic cinder to carry off the fixed impurities, including phosphates which may result from the oxidation of the phosphorus of the iron. That the fluor-spar may both serve to form the flux and quicken the separation of the silicon and phosphorus, was fully established by Carron.

A large quantity of iron oxides appears in this cinder, in the above statement of the analysis, equivalent to fifty-eight per cent. of the whole slag. But it is probable that most of this was derived from the powdered ilmenite (titanic iron oxide) used in the process. In the ordinary puddling slag the large proportion of iron oxide always present is derived from the pig iron. It is very probable that the mixture of the powdered iron ore with the fluor-spar may lessen the loss of metal in the puddling. According to the published statement, the loss in purifying the most common pig iron into fine wrought iron, by the Henderson process, is only ten per cent.

It is generally believed that, in the ordinary refining processes, the agent which is especially effectual in the removal of the phosphorus is the tri-basic silicate of iron, which forms a fluid cinder or slag, and which is produced by the oxidation of the ingredients of the pig metal at a great expense of iron. There can be no doubt that this loss may be measurably prevented, and the purification facilitated, by the use of a "lining" of powdered oxide of iron (iron ore), with some compound of lime (fluor-spar or limestone), to give oxygen and form a fluid basic flux to carry off the phosphoric and silicic acids, &c. Whether the use of similar materials, to furnish oxygen and the ingredients for a somewhat basic flux to carry off phosphoric acid, is possible in the Bessemer process, is well worthy of trial. Fluor-spar commends itself because of its ready fusibility and its power of fluxing earthy materials generally, so that it possibly may dissolve, retain, and protect from reduction the oxidated phosphatic compounds, at a temperature sufficient to melt iron, and thus aid in their removal. The presence of alumina in the cinder seems also to be beneficial in this respect.

Not the least interesting of the iron ores analyzed, during the past year, are those described in the Appendix as Clinton iron ore, dyestone ore, or fossil ore, from very extensive beds in the mountainous region of Tennessee, near the Kentucky State line, in the Cumberland Gap region, which, because of

their abundance in the vicinity of our coal beds, their general richness in iron (one sample giving more than fifty-six per cent. of this metal, on analysis), as well as because of their unexpected moderate proportion of phosphorus, in this locality, promise to become of great industrial value.

Some of the iron smelted from this Clinton ore, at the Old Clinton Furnace, at Cumberland Gap, the analysis of which is also given in the Appendix, corroborates this expectation.

The twenty-two samples of pig iron analyzed, from five counties of the State, vary in their specific gravity from 6.163 to 7.435; in their per centage of *iron*, from 89.687 to 94.764; in their per centage of *total carbon*, from 2.800 to 4.720; in that of *phosphorus*, from 1.080 to 0.120; in that of *silicon*, from 5.082 to 0.363, and in that of *sulphur*, from 0.278 to 0.011. This includes samples of hot-blast stone-coal iron, as well as cold-blast charcoal iron. From these and the analyses previously made, it is evident that iron of almost any desirable quality can be manufactured in our State from her natural products, which are unusually abundant, and await only the judicious application of capital, skill, and labor to give to her great prominence as a manufacturing State.

An interesting discovery of a phosphatic layer in the blue limestone (Lower Silurian) is recorded under the head of Fayette county; and some suggestions as to the use of the Bittern water of our salt works, and other means in rendering more available for fertilizers the beds of marls of our State, will be found under the heads of Clay and Grayson counties.

Another interesting fact reported is the existence of barium and strontium chlorides in the brines of Clay and Meade counties.

BATH COUNTY.

Limonite iron ores, labeled as follows:

No. 1652.—LIMONITE, *from Slate Furnace ore banks, "Howard's Hill;" Upper Silurian formation. Collected by P. N. Moore.*

In porous, or fine cellular, irregular, thin laminæ; oölitic in parts; of a dark-brown color, with ochreous incrusting material.

No. 1653—LIMONITE, *from Slate Furnace ore bank. Upper part of the bed. Collected by P. N. Moore.*

Mostly of a yellowish-brown color, and somewhat friable, with some darker-brown and denser irregular laminæ. The whole presenting a fine-grained oölitic appearance, from the presence of small spherical cavities, more or less incrusted with whitish and yellowish material.

No. 1654—LIMONITE ORE *at the Chalybeate Springs, Pilot Knob. Collected by P. N. Moore.*

In thin irregular laminæ, of a dark reddish-brown color, with some bright red and yellowish ochreous material.

No. 1655—LIMONITE (*with carbonate*), *said to be eighteen to twenty feet thick, from near Owingsville, on the road to Slate Creek. Collected by P. N. Moore.*

Of a fine oölitic structure. Colors varying from yellowish and reddish-brown to greyish-brown, with greenish-grey infiltration in some parts.

No. 1656—LIMONITE, *from "Old Coaling Bank," head of Clear Creek; in Sub-carboniferous limestone. Average sample collected by P. N. Moore.*

Principally of a dark reddish-brown color, with some little of lighter color.

No. 1657—LIMONITE, *from the "Richardson Bank," Clear Creek; in Sub-carboniferous limestone. Average sample collected by P. N. Moore.*

A dense ore, generally of a dark brown color, with a small proportion of greyish.

No. 1658—LIMONITE, *from the "Pergam Bank," Clear Creek; in Sub-carboniferous limestone. Average sample collected by P. N. Moore.*

A dense ore, generally of a dark brown color, with some little ochreous.

COMPOSITION OF THESE BATH COUNTY LIMONITE ORES, DRIED AT 212° F.

	No. 1652	No. 1653	No. 1654	No. 1655	No. 1656	No. 1657	No. 1658
Iron peroxide	70.060	69.728	47.321	39.068	59.621	66.329	65.310
Iron carbonate	....	....	....	11.479	....	....	....
Alumina	4.540	8.642	5.418	8.346	12.370	12.532	11.947
Manganese peroxide	not est.	not est.	not est.	not est.	not est.	not est.	not est.
Lime carbonate	.040	.170	.690	18.710	.500	a trace.	.730
Magnesia	.021	.045	.079	6.159	.144	.173	.140
Phosphoric acid	1.620	1.154	.161	.868	.709	.709	.825
Sulphuric acid	.031	.134	.376	.185	a trace.	a trace.	a trace.
Combined water	12.300	12.650	12.050	7.835	10.400	9.580	11.000
Silicious residue	11.530	7.930	33.330	7.350	15.830	9.720	9.580
Total	100.142	100.453	99.425	100.000	99.574	99.043	99.532
Iron, per cent.	49.042	48.809	33.125	30.734	41.735	46.440	44.570
Phosphorus, per cent.	0.707	.504	.070	.379	.309	.309	.360
Sulphur, per cent.	.012	.053	.150	.074	a trace.	a trace.	a trace.
Silica, per cent.	11.530	7.760	27.600	7.560	13.960	9.060	9.580
Specific gravity	3.470	3.405	not est.	not est.	not est.	not est.	not est.

All of these ores are sufficiently rich for profitable smelting. Nos. 1652, 1653, and 1657 are more than usually rich in iron. The first two contain more phosphorus than is desirable, but much of this may be removed in the slag, if there be much alumina present; moreover, it would not be seriously objectionable in ordinary castings. No. 1655, containing quite large proportions of lime and magnesia, might profitably be mixed with more silicious and richer ores for smelting. Sulphur is not superabundant, except in No. 1654.

PIG IRON FROM BATH COUNTY.

No. 1659—LABELED "*No. 1 Cold-blast Charcoal Iron; Bath Furnace. Collected by P. N. Moore.*"

A dark-colored, moderately coarse-grained iron. Yields readily to the file; flattens considerably under the hammer.

No. 1660—"*Pig Iron from Old Slate Furnace.*" *Collected by P. N. Moore.*

Finer-grained, harder, and less tough than the preceding, but yields to the file and extends somewhat under the hammer.

No. 1661—LABELED "*No.* 1 *Cold-blast Charcoal Car-wheel Iron,*" *from Cottage Furnace. Sent by G. S. Moore & Co., of Louisville.*

Moderately coarse-grained; somewhat dark grey. Yields with difficulty to the file; extends somewhat under the hammer.

No. 1662—"*No.* 2 *Cold-blast Charcoal Pig Iron,*" *from Bath Furnace. Collected by P. N. Moore.*

A moderately fine-grained grey iron. Yields to the file; extends considerably under the hammer.

No. 1663—"*No.* 3 *Cold-blast Charcoal Pig Iron,*" *from Bath Furnace. Collected by P. N. Moore.*

Finer-grained than the preceding. Yields to the file; extends rather more under the hammer than the preceding.

No. 1664—"*No.* 4 *Cold-blast Charcoal Pig Iron, from Bath Furnace. Collected by P. N. Moore.*"

Finer-grained than the preceding. Quite fine-grained, and dark grey. Yields to the file; extends somewhat under the hammer.

COMPOSITION OF THESE BATH COUNTY PIG IRONS.

	No. 1659.	No. 1660.	No. 1661.	No. 1662.	No. 1663.	No. 1664.
Iron	92.631	92.056	93.106	91.924	93.472	93.004
Graphite	3.840	3.640	3.860	3.440	3.100	2.700
Combined carbon	.710	.310	.590	1.060	1.510	1.410
Silicon	1.520	1.760	.914	1.319	.652	1.007
Slag	.100	.100	.160	.260	.160	.260
Calcium	.090	.116	not est.	not est.	not est.	not est.
Phosphorus	.363	1.080	.527	.220	.290	.262
Sulphur	.278	.218	.011	.107	.121	.172
Total	99.532	99.280	99.168	98.330	99.305	98.815
Total carbon	4.550	3.950	4.450	4.500	4.610	4.110
Specific gravity	7.070	7.067	7.142	7.017	7.092	7.168

The pig iron of the Bath Furnace has a well deserved reputation for yielding iron of great tenacity, and hence is preferred for railroad axles. Its small proportion of phosphorus* does not seem to injure it in this respect. It, as well as the other specimens from Bath county, contains more than the usual proportion of carbon. The iron of the Old Slate Furnace, prepared from the phosphatic ores of the Upper Silurian Group, contains more phosphorus than is desirable in the manufacture of tough bar iron or steel. This impurity does not prevent it from being available in almost all ordinary castings.

BARREN COUNTY.

No. 1665—"*Marly Deposit in Proctor's Cave. In the cavernous Sub-carboniferous limestone, Barren county.*" *Said to be good for polishing metals.*

The dried lumps are very fine-grained, and are light-grey, nearly white. Adhere to the tongue.

COMPOSITION, DRIED AT 212° F.

Lime carbonate	66.160
Magnesia carbonate	14.083
Alumina and iron and manganese oxides, and phosphoric acid	5.800
Water, alkalies, and loss	5.097
Silica and insoluble silicates	8.860
Total	100.000

If in sufficient quantity, it might not only be useful for polishing the soft metals, but might be used as a fertilizer, or, very probably, it would make a hydraulic cement, if properly calcined.

No. 1666—"NITRE EARTH. *From Grand Avenue Cave, three miles northwest of Glasgow Junction, Barren county. Collected by Prof. N. S. Shaler.*"

A light cinnamon-colored earth, containing excrements of bats, &c., &c.

*It is believed by the writer that, in consequence of the difficulties attending the estimation of the phosphorus in iron, this ingredient has been often under-estimated by chemists, and, consequently, its evil influence has been over-estimated.

Qualitatively examined, it was found to contain ammonia salt, or some nitrogenous matter which yields this alkali under the action of lime; also much lime sulphate.

Quantitative analysis showed, however, that it only contained of nitric acid 0.0025 per cent.; of potash, .0129 per cent.; of soda, .0024; so that it would not prove valuable as a source of nitre, although, if in sufficient quantity, it might be useful as a fertilizer.

BELL COUNTY.

COALS OF BELL COUNTY.

No. 1667—"*Coal, from Abraham Lock's coal bank, Straight Creek, Bell county. Collected by A. R. Crandall.*"

A somewhat soft, pure-looking splint coal. Very little fibrous coal and no pyrites apparent. Some ferruginous stain in the seams.

No. 1668—"*Cannel Coal, from Col. John G. Eve's land, Fork Ridge, near Stony Creek. Fourteen inches thick. Taken from the bed of Mountain Creek. It is probably better beyond the opening.*"

Tough; fracture somewhat conchoidal; lustre satiny. No appearance of pyrites. Some ferruginous stain on the surface.

No. 1669—"*Hignite Coal, from Hignite Branch of Yellow Creek. Upper bed. Collected by A. R. Crandall.*"

A splint coal, with very little fibrous coal or granular pyrites between the laminæ.

No. 1670—"*Coal, from the same locality as the last sample. Middle bed. Collected by A. R. Crandall.*"

Does not differ much in appearance from the preceding.

No. 1671—"*Coal, from the same locality. Lower bed. Collected by A. R. Crandall.*"

No. 1672—"*Coal, from Little Clear Creek. In the shales above the Conglomerate. Bed two feet thick; fifteen feet above the creek. Collected by A. R. Crandall.*"

A semi-cannel or splint coal. Very little fibrous coal and no apparent pyrites between the laminæ. Lumps slightly soiled with mud.

No. 1673— *Coal, from Little Clear Creek, &c., &c. Bed two feet thick, in the bed of the creek. Collected by A. R. Crandall.*"

Resembles the last. Some little ferruginous stain on exterior surfaces.

No. 1674—"*Coal, from Fork Ridge, on Stony Creek. A four-feet bed, above the cannel coal. Collected by A. R. Crandall.*"

A pitch-black, pure-looking coal. Has very little fibrous coal and no apparent pyrites.

No. 1675—"*Coal, from James Barnett's bank, six miles north of Cumberland Gap, on a branch of Clear Fork, which runs into Big Yellow Creek. Bed forty inches thick, with no shale parting. Average sample collected by Jno. H. Talbutt. (Three other beds in the same hill; one below, eighteen inches thick; two above—one eighteen inches, the other, on the top, about three to four feet thick.)*"

A pure, glossy, pitch-black coal. Has very little fibrous coal or pyrites.

No. 1676—"*Coal, from the same locality as the last. A sample from such as is sent to market.*" *Collected by John H. Talbutt.*"

Resembles the preceding.

COMPOSITION OF THESE BELL COUNTY COALS, AIR-DRIED.

	No. 1667.	No. 1668.	No. 1669.	No. 1670.	No. 1671.	No. 1672.	No. 1673.	No. 1674.	No. 1675.	No. 1676.
Specific gravity.	1.276	1.262	1.346	1.290	1.277	1.360	1.325	1.344	1.282	not est.
Hygroscopic moisture. . .	1.90	1.00	1.80	2.04	2.96	1.02	1.76	1.26	1.36	1.50
Volatile combus'ble matters	37.50	43.60	35.50	36.64	35.28	37.76	38.90	33.96	35.80	37.94
Coke	60.60	55.40	62.70	61.32	61.76	61.22	59.34	64.78	62.84	60.56
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Total volatile matters . . .	39.40	44.60	37.30	38.68	38.24	38.78	40.66	35.22	37.16	39.44
Carbon in the coke	57.90	47.80	52.20	58.02	59.40	48.22	52.54	55.42	59.54	58.40
Ash	2.70	7.60	10.50	3.30	2.36	13.00	6.80	9.36	3.30	2.16
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Character of the coke. . .	*Lt. sp.	Dense sp.	Lt. sp.	Lt. sp.	Lt. sp.	Lt. sp.	Lt. sp.	Lt. sp.	Lt. sp.	Lt. sp.
Color of the ash	Light brown.	Buff-grey.	Very light grey.	Light lilac-grey.	Brownish-grey.	Lilac-grey.	Lilac-grey.	Light lilac-grey.	Buff-grey.	Brownish-buff.
Per centage of sulphur . .	1.519	0.590	0.956	0.736	0.420	1.670	2.027	2.672	0.975	1.038

* Lt. sp. — Light spongy.

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These coals are all good, and some of them would rank amongst the very best, and might be made available in the smelting of iron ores without the preliminary process of coking, like the so-called "Block coal" of Indiana, which they resemble. The proportion of sulphur, it will be seen, is generally sufficiently low, but varies in the different samples from 0.42 per cent., in No. 1671, up to 2.672, in No. 1674. It must be remembered that these proportions given in the table represent the *total sulphur* of the coals, in whatever form it may exist in them, and that, in the practical use of the coal for smelting or manufacturing purposes, a considerable proportion of this total sulphur is removed in the preliminary heating in the upper part of the furnace, or in the coking of the coals, or is in such a state of combination in them as to be harmless.

As shown in volume I, new series, of these reports (lower page 287), some of this sulphur is in the free or uncombined condition, especially in the fibrous coal, or mineral charcoal, which is found between the laminæ. When in this state this injurious element is quite easily removable. Indeed, it is continually undergoing oxidation, when the coal is exposed to the air, even at the ordinary temperature, forming, with the atmospheric oxygen and moisture, sulphurous acid, which, being gaseous, is constantly escaping, causing the well-known sulphurous odor of the coal mine or coal heap, and enabling us to understand how it is that coals gradually become less sulphurous on exposure to the air. When the coals are heated the rate of the evaporation and oxidation of the sulphur is rapidly increased, so that at 300° F. or below it takes fire. Hence, none of the free sulphur of the coals used in the smelting of iron ever gets much below the top of the furnace, where it can do no harm, and all of it is burnt out even before the heat is sufficiently great to coke the coal. Possibly much of it escapes in the process of heating the coals to 212° F., with a view to ascertain the proportion of hygroscopic moisture, thus increasing the apparent quantity of that ingredient

—a supposition which will be made subject of further investigation.*

Some of the sulphur of coals exists in combination with iron, as sulphide or bi-sulphide. When it is in the form of bi-sulphide, one half of the sulphur of the compound is always burnt out in the process of coking, or in the upper part of the smelting furnace.

It will be seen, therefore, that while a portion of the sulphur of coals may, in the ordinary process of analysis, cause an error of excess in the estimation of the hygroscopic moisture, another portion increases the quantity of so-called volatile and combustible matters. Still another portion may, on incineration of the coke, be miscounted as fixed carbon.

That portion of the sulphur of coals which is not removed by the process of coking or preliminary heating is either in combination with iron, as iron proto-sulphide, which may injure the quality of the metal smelted with it, or it is most probably in combination with calcium, magnesium, or the alkaline metals, in which form it probably exerts little or no injurious action. Hence, as practical experience has measurably demonstrated, a coal may show a pretty large proportion of total sulphur in its chemical analysis, and yet answer for the smelting or working of iron when properly managed.

Even the iron proto-sulphide, which is the most injurious of all the forms of sulphur in coals or coke, may be easily removed, because it speedily oxidates into iron proto-sulphate when exposed to a moist atmosphere; and this salt, being quite soluble in water, is readily to be washed out.

It is interesting again to notice in this series of coals the pretty constant relation between the specific gravity and the ash per centage, as follows:

* As stated by Berzelius, all the sulphur may be burnt out of gunpowder at the heat of boiling water without exploding the powder. Examined in the dark, a faint flame appears above it, in this experiment.

Number.	Ash per centage.	Specific gravity.	Number.	Ash per centage.	Specific gravity.
1667	2.70	1.276	1668*	7.60	1.262
1671	2.36	1.277	1674	9.36	1.344
1675	3.30	1.282	1669	10.50	1.346
1670	3.30	1.290	1672	13.00	1.360
1673	6.80	1.325			

*A cannel coal.

Bell county, undoubtedly, is endowed with great wealth of coal of every good quality, as well as of iron ores, &c.; which only await development.

SOILS AND SUBSOILS OF BELL COUNTY.

No. 1677—"*Virgin Soil, John Turner's land, in the valley of Big Yellow Creek, three and a half miles west of Cumberland Gap. Bell county crawfish land; subject to overflow in high water. Timber: some trees five feet in diameter; burr-oak, beech, sweet gum, maples, poplar, sycamore, &c., &c. On the coal measures. Collected by John H. Talbutt.*"

Soil a light buff-grey color when dry; cloddy; clods mottled with light-ferruginous.

No. 1678—"*Old Field Soil, sixty years in cultivation, mostly in corn; John Turner's land. Same locality as virgin soil. Sample taken to the depth of thirteen inches. Field lies at the base of Fork Ridge of Canada Mountain, between Bennett's Fork and Stony Fork. An ancient mound exists on the same land, which is said to have had the remains of ancient earthworks on it. Many flint implements found on it. Collected by J. H. Talbutt.*" *Substratum of rounded sandstone boulders and pebbles; on coal measures.*

Soil of a light umber color.

No. 1679—"*Subsoil of the preceding, &c. Collected by J. H. Talbutt.*"

Subsoil of a light grey-buff color.

No. 1680—"*Virgin Soil to depth of three inches. Woods. B. F. Turner's land, three miles west of Cumberland Gap, on the foot-hills of Big Yellow Creek. Slope to the south. Timber: oak, beech, poplar, with underbrush. Coal measures. Collected by John H. Talbutt.*"

No. 1681—"*Subsoil to the preceding. Collected by J. H. Talbutt.*"

Subsoil of a buff color.

No. 1682—"*Soil from a field which has been cleared ten years. Has been six years in corn and four in pasture. Average yield thirty bushels of corn. Surface soil. The land slopes gently to the south. Woodland above it and to the north. Coal measures. Collected by John H. Talbutt.*"

Soil of a light buff-umber color.

No. 1683—"*Subsoil of the preceding. Collected by J. H. Talbutt.*"

Subsoil of a light buff-grey color.

No. 1684—"*Virgin Surface Soil, from the narrow plateau on the highest point of Brison Mountain, a fork of Mingo Ridge, near the line of Bell county. Eleven miles south-southeast of Cumberland Gap. Sample taken to the depth of nine inches. Underlying rock sandstone. Has on it a fair growth of chestnut, oak, sugar-tree, poplar, hickory, &c., &c. Collected by John H. Talbutt.*"

Soil of a dark grey-brown or umber color when dry; nearly black when wet.

No. 1685—"*Subsoil of the preceding. Collected by John H. Talbutt.*"

Subsoil of a lighter color and more sandy than the surface soil.

No. 1686—"*Vigin Soil, from the foot-hills of Mingo Mountain, Big Yellow Creek Valley. Land of William T. Moss. Slope to the north. Timber: black oak, dogwood, maple, chestnut, &c., &c. Sampled to the depth of ten inches by John H. Talbutt.*"

Soil of a dirty grey-buff color.

No. 1687—"*Soil from an old field fifty years in cultivation—thirty-five in corn without change, seven years thereafter in clover and grass, and then two years in corn; now in wheat. Average yield: of corn, forty bushels; of wheat, ten bushels. Timber was black walnut, burr-oak, poplar, gum, maple, sycamore, &c. Land of William T. Moss. In Big Creek Valley, near the head of Big Yellow Creek. Carboniferous formation. Top soil seventeen inches deep. Collected by John H. Talbutt.*"

Soil of a light, grey-umber color.

No. 1688—"*Subsoil to the preceding; taken eighteen inches below the surface. Collected by John H. Talbutt.*"

Subsoil lighter colored than the surface soil preceding.

No. 1689—"*Soil from an old field in cultivation seventy years. Farm of Henry Lane. Foot-hills of Mingo Mountains, Big Yellow Creek Valley, three and a half miles from Cumberland Gap. Cultivated for the last ten years in corn and wheat alternately; previous to which in corn for twenty-five years; now in wheat. Originally covered with a dense forest of black walnut, burr-oak, beech, poplar, sycamore, and gum. Yield of corn, thirty to forty-five bushels; of wheat, fifteen bushels. Value of the land, fifty dollars per acre. On the carboniferous formation. Sampled to the depth of fifteen inches, by John H. Talbutt.*"

Soil of a yellowish-grey, light umber color.

No. 1690—"*Subsoil of the preceding. Collected by John H. Talbutt.*"

Subsoil of a lighter and more yellowish color than the surface soil preceding.

No. 1691—"*Soil to the depth of nine inches from an old field now in corn, on John Colson's land, foot of Cumberland Range, near Cumberland Gap. Slope to the west. On coal measures. Collected by J. H. Talbutt.*"

Dried soil of a light, brownish-umber color. Contains many small fragments of decaying vegetable roots, &c., and some small rounded quartz pebbles, and fragments of ferruginous sandstone.

No. 1692—"*Subsoil of the preceding,*" *&c., &c.*

Of an orange-grey-buff color. Much lighter colored and more cloddy and adhesive than the preceding, and containing fewer pebbles. The silicious residue of both of these, after digestion in acids, contained a considerable quantity of small rounded, clear quartz grains.

No. 1693—*Surface Soil to five inches in depth, from a field ten years in cultivation; now in corn, of which it yields about twenty bushels. J. C. Colson's land, one mile west of Cumberland Gap; foot-hills of Dark Ridge. Slope to the southeast. Carboniferous formation. Collected by John H. Talbutt.*"

Soil of a dirty buff-grey color. The coarse sieve removed from it some small fragments of ferruginous sandstone. The silicious residue all passed through fine bolting-cloth, except a very few small clear quartz grains.

No. 1694—"*Subsoil of the preceding. Collected by John H. Talbutt.*"

Resembles subsoil No. 1692, but is a little lighter colored and more cloddy. Contains no silicious sand.

No. 1695—"*Top Soil to depth of nine inches, from an old field fifty years in cultivation. For the last twenty-five years in corn, wheat, oats, and clover; two thirds of time in corn. Average yield of which, thirty bushels per acre. Does not produce good wheat or oats. J. C. Colson's land. North side of Big Yellow Creek Valley, near the foot-hills of Log Moun-*

No. 1686—"*Vigin Soil, from the foot-hills of Mingo Mountain, Big Yellow Creek Valley. Land of William T. Moss. Slope to the north. Timber: black oak, dogwood, maple, chestnut, &c., &c. Sampled to the depth of ten inches by John H. Talbutt.*"

Soil of a dirty grey-buff color.

No. 1687—"*Soil from an old field fifty years in cultivation—thirty-five in corn without change, seven years thereafter in clover and grass, and then two years in corn; now in wheat. Average yield: of corn, forty bushels; of wheat, ten bushels. Timber was black walnut, burr-oak, poplar, gum, maple, sycamore, &c. Land of William T. Moss. In Big Creek Valley, near the head of Big Yellow Creek. Carboniferous formation. Top soil seventeen inches deep. Collected by John H. Talbutt.*"

Soil of a light, grey-umber color.

No. 1688—"*Subsoil to the preceding; taken eighteen inches below the surface. Collected by John H. Talbutt.*"

Subsoil lighter colored than the surface soil preceding.

No. 1689—"*Soil from an old field in cultivation seventy years. Farm of Henry Lane. Foot-hills of Mingo Mountains, Big Yellow Creek Valley, three and a half miles from Cumberland Gap. Cultivated for the last ten years in corn and wheat alternately; previous to which in corn for twenty-five years; now in wheat. Originally covered with a dense forest of black walnut, burr-oak, beech, poplar, sycamore, and gum. Yield of corn, thirty to forty-five bushels; of wheat, fifteen bushels. Value of the land, fifty dollars per acre. On the carboniferous formation. Sampled to the depth of fifteen inches, by John H. Talbutt.*"

Soil of a yellowish-grey, light umber color.

No. 1690—"*Subsoil of the preceding. Collected by John H. Talbutt.*"

Subsoil of a lighter and more yellowish color than the surface soil preceding.

No. 1691—"*Soil to the depth of nine inches from an old field now in corn, on John Colson's land, foot of Cumberland Range, near Cumberland Gap. Slope to the west. On coal measures. Collected by J. H. Talbutt.*"

Dried soil of a light, brownish-umber color. Contains many small fragments of decaying vegetable roots, &c., and some small rounded quartz pebbles, and fragments of ferruginous sandstone.

No. 1692—"*Subsoil of the preceding,*" *&c., &c.*

Of an orange-grey-buff color. Much lighter colored and more cloddy and adhesive than the preceding, and containing fewer pebbles. The silicious residue of both of these, after digestion in acids, contained a considerable quantity of small rounded, clear quartz grains.

No. 1693—*Surface Soil to five inches in depth, from a field ten years in cultivation; now in corn, of which it yields about twenty bushels. J. C. Colson's land, one mile west of Cumberland Gap; foot-hills of Dark Ridge. Slope to the southeast. Carboniferous formation. Collected by John H. Talbutt.*"

Soil of a dirty buff-grey color. The coarse sieve removed from it some small fragments of ferruginous sandstone. The silicious residue all passed through fine bolting-cloth, except a very few small clear quartz grains.

No. 1694—"*Subsoil of the preceding. Collected by John H. Talbutt.*"

Resembles subsoil No. 1692, but is a little lighter colored and more cloddy. Contains no silicious sand.

No. 1695—"*Top Soil to depth of nine inches, from an old field fifty years in cultivation. For the last twenty-five years in corn, wheat, oats, and clover; two thirds of time in corn. Average yield of which, thirty bushels per acre. Does not produce good wheat or oats. J. C. Colson's land. North side of Big Yellow Creek Valley, near the foot-hills of Log Moun-*

tain, three miles northwest of Cumberland Gap. Carboniferous formation. Collected by John H. Talbuti."

Soil resembles No. 1693.

No. 1696—"*Subsoil of the preceding, taken one foot below the surface. By John H. Talbutt.*"

Subsoil of a reddish-brown, grey-buff color. Contains very few grains of fine quartz sand.

COMPOSITION OF THESE BELL COUNTY SOILS AND SUBSOILS, DRIED AT 212° F.

	No. 1677	No. 1678	No. 1679	No. 1680	No. 1681	No. 1682	No. 1683	No. 1684	No. 1685	No. 1686
Organic and volatile matters	4.700	5.575	2.600	5.725	2.750	5.050	1.800	11.565	5.750	4.050
Alumina, Iron peroxide, Manganese oxide	4.817	4.015	1.710	4.339	4.137	3.557	2.474	4.615	4.662	4.197
Lime carbonate	.190	.190	.115	.065	.065	.265	.115	.145	.145	.095
Magnesia	.338	.069	.045	.050	.042	.131	.060	.098	.079	.068
Phosphoric acid	.093	.220	.125	.096	.073	.093	.061	.125	.108	.093
Sulphuric acid	not est.	not est.	not est.	not est.	not est.	not est.	not est.	not est.	not est.	not est.
Potash	.164	.160	.056	.068	.106	.212	.086	.139	.131	.128
Soda	.115	.217	.006	.035	.032	. . . .	.014	.074	.039	not est.
Sand and insoluble silicates	89.390	88.875	93.940	89.390	92.090	90.215	95.115	84.040	88.540	90.440
Water, expelled at 380° F.	.600	.775	.900	.650	.850	.750	.750	.035	.900	.750
Loss	. . . .	. . . .	.503	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	.179
Total	100.407	100.096	100.000	100.418	100.145	100.273	100.475	100.836	100.354	100.000
Moisture, lost at 212° F.	1.825	2.550	1.350	1.800	0.875	1.875	0.850	3.700	2.275	1.475
Potash in the insoluble silicates	2.568	.735	.850	.568	.713	.347	.501	.583	.717	1.387
Soda in the insoluble silicates	.389	.018	.082	.119	.137	.167	.216	.090	.150	.213
Character of the soil	Virgin soil.	Old field	Subsoil.	Virgin soil.	Subsoil.	Old field	Subsoil.	Virgin soil.	Subsoil.	Virgin soil.

COMPOSITION OF THESE BELL COUNTY SOILS AND SUBSOILS, DRIED AT 212° F.—(Continued.)

	No. 1687	No. 1688	No. 1689	No. 1690	No. 1691	No. 1692	No. 1693	No. 1694	No. 1695	No. 1696
Organic and volatile matters	5.925	4.850	5.525	4.725	3.500	2.450	4.125	4.025	7.175	5.675
Alumina, Iron peroxide, Manganese oxide	8.846	8.120	7.339	7.013	2.913	2.815	5.990	6.997	9.626	12.816
Lime carbonate	.280	.095	.095	.095	.290	.275	.225	.225	.265	.115
Magnesia	.052	.088	.088	.088	.070	.044	.080	.081	.155	.322
Phosphoric acid	.124	.093	.061	.077	.093	.125	.125	.093	.189	.294
Sulphuric acid	not est.	not est.	not est.	not est.	.007	.003	.007	.007	.007	.013
Potash	.139	.191	.143	.243	.158	.203	.109	.368	.429	.443
Soda	.085	.117	.063	....	.050	.013	.177	....	.190	....
Sand and insoluble silicates	83.140	86.040	85.140	87.125	92.090	92.040	87.590	86.815	80.040	78.240
Water, expelled at 380° F.	1.100	.750	1.200	1.000	1.100	1.050	1.450	1.250	2.075	2.025
Loss	.309	....	.346	....	....	.982	.122	.139	....	.057
Total	100.000	100.344	100.000	100.366	100.271	100.000	100.000	100.000	100.151	100.000
Moisture, lost at 212° F.	2.450	1.875	2.225	1.900	1.150	1.175	1.500	1.515	2.500	2.525
Potash in the insoluble silicates	2.509	2.275	2.362	2.351	.496	.674	1.831	1.964	2.519	2.640
Soda in the insoluble silicates	.344	.251	.273	....	.169	.186	.561	.348	.303	.464
Character of the soil	Old field	Subsoil.	Old field	Subsoil.	Old field	Subsoil.	Field 10 years in cultiv'n.	Subsoil.	Old field	Subsoil.

As might have been expected, considerable local differences are exhibited by the chemical analyses of these mountain soils, caused, probably, in most cases, by the action of the drainage; as may be seen by comparing the relative proportions of the potash, phosphoric acid, the organic and volatile matters, lime, magnesia, and alumina, &c., &c., with the silex and insoluble silicates, as well as by the relative quantities of alkalies in the insoluble silicates.

Thus the soils of the valley, or those subject to overflow, as for example, Nos. 1687–'8–'9–'90, as well as 1693–'4–'5–'6, located in the valley, are richer than those on the mountain slopes. A remarkable difference in the proportions of phosphoric acid can be observed in soils Nos. 1677 and 1678, which may possibly have been caused by the residence on the latter of the prehistoric people who built and occupied the ancient earth-works located there.* The subsoil No. 1679, underlying the latter, is by no means as rich as the surface soil, based as it is on a substratum of rounded sandstone boulders and pebbles, and no doubt offering quite a free drainage to the waters from above, which tend to wash away the soluble ingredients.

The soil from the plateau, at the summit of Brison Mountain, No. 1684, is much richer than might have been expected. Its large proportions of organic and volatile matters, as well as of alkalies in the insoluble silicates, indicate the influence of the primeval forest growth, with which it is yet covered, in retaining the elements of fertility on the surface. The unusually large proportion of silicates, rich in alkalies, in the rock material from whence the soil was derived, may have been another cause.

BOONE COUNTY.

No. 1697—"CLAY, *from three miles west of Burlington. Sent by W. W. Walton.*"

Presents thin stratified layers of various tints of light-brownish-grey and light dove color. Burns hard, and of a

* A similar increase in the proportion of phosphates on and near the site of these prehistoric earth-works was observed in Fayette county, on the farm of the writer.

handsome light brick color. Melts at a high temperature; hence, is not a fire-clay.

COMPOSITION, DRIED AT 212° F.

Alumina, with iron and manganese oxides and phosphoric acid	33.060
Silica	48.360
Lime	3.057
Magnesia	.367
Potash	4.664
Soda	1.706
Combined water and loss	8.786
Total	100.000

While its large proportions of alkalies and of lime, as well as of iron oxide, prevent it from withstanding the melting influence of a high heat, it may yet be quite available for so-called *terra cotta* articles. It is probable, also, that, if found in sufficient quantity, it may be quite useful in the improvement of worn-out sandy soils in its vicinity.

BOYD COUNTY.

No. 1698—"GREY LIMESTONE ORE, *from J. P. Jones' drift, near Ashland. Collected by P. N. Moore.*"

Interior portion—Grey clay iron-stone, made up of fine light-brownish granules, embedded in a whitish material. *Exterior portion*—Generally dark reddish-brown, with some little lighter ferruginous and ochreous, the whole exhibiting a fine granular or oölitic structure, and showing the same whitish material observed in the grey interior portion.

The analyses of the interior and exterior portions were made separately, with a view to the study of the changes which occur when clay iron-stone is changed into limonite.

Similar comparative analyses are recorded under Carter county.

No. 1699—"YELLOW KIDNEY ORE. *Point of hill. Catlettsburg, Boyd county. Collected by A. R. Crandall. A cabinet specimen.*"

A kidney of fine-grained iron carbonate, invested with thin layers of reddish and yellowish-brown and brownish-yellow limonite.

Interior and exterior portions separately analyzed.

COMPOSITION OF THESE ORES, DRIED AT 212° F.

	No. 1698.		No. 1699.	
	Interior.	Exterior.	Interior.	Exterior.
Iron carbonate	62.002	none.	69.912	none.
Iron peroxide	none.	65.395	none.	61.142
Alumina	2.900	3.484	6.128	7.964
Manganese carbonate	.553	....		.....
Manganese oxide	.....	not est.	not est.	not est.
Lime carbonate	6.880	8.580	8.280	3.530
Magnesia	*2.243	1.938	*3.314	.424
Phosphoric acid	.149	.441	.686	.414
Sulphuric acid	.302	.336	.147	.199
Combined water	.....	9.346	.....	12.600
Silicious residue	22.660	10.480	8.930	14.180
Total	97.689	100.000	97.397	100.453
Per centage of iron	29.932	45.776	33.751	42.799
Per centage of phosphorus	.065	.192	.299	.181
Per centage of sulphur	.121	.134	.059	.080
Per centage of silica	16.360	9.360	7.460	11.860

* Carbonate.

Taking for a basis of comparison the relative quantities of *iron* in the two portions, which are nearly in the proportions of one in the interior part to one and a half in the exterior in No. 1698, and somewhat less in No. 1699 (or as 1 : 1.27), we find that in the former there has been a notable increase of phosphorus, a slight increase of lime, a great diminution in the proportion of silica, and slight diminutions in the proportions of sulphur, magnesia, and alumina; in specimen 1699, a decrease in the phosphorus, and an increase in the sulphur, silica, and alumina. The lime and magnesia are also greatly diminished. So that there seems to be no regular law in relation to the changes which occur; which may be effected by very varying conditions of chemical action and infiltration.

PIG IRONS FROM BOYD COUNTY.

No. 1700—"*Pig Iron. Hot-blast. Mill iron, from Bellfonte Furnace. Collected by P. N. Moore.*"

A fine-grained, dark-grey iron. Yields readily to the file. Extends quite considerably under the hammer.

No. 1701 — "*Hot-blast, Silver-grey Iron, Bellfonte Furnace. Collected by P. N. Moore.*"

Coarser grained than the preceding; somewhat harder and more brittle. Of a light silver-grey color.

COMPOSITION OF THESE PIG IRONS.

	No. 1700.	No. 1701.
Specific gravity	6.921	6.163
Iron	92.962	89.902
Graphite	2.100	2.900
Combined carbon	1.310	.070
Silicon	2.525	5.082
Slag	.220	.280
Phosphorus	.568	.417
Sulphur	.114	.114
Other ingredients	not est.	not est.
Total	99.799	98.765
Total carbon	3.410	2.970

The principal difference in the composition of these two samples is in the much larger proportion of silicon and somewhat smaller amount of iron in No. 1701.

BREATHITT COUNTY.

COALS FROM BREATHITT COUNTY.

No. 1702—"*Coal, from Roberts' bank, on Troublesome Creek. Upper seam. The so-called bituminous coal. Collected by P. N. Moore.*"

A splint coal, splitting into very thin laminæ, with fibrous coal between, but with no appearance of pyrites. The sample has a weathered and tarnished appearance, showing ferruginous and earthy stains. Hence, the ash per centage found is greater than that of the clean coal of the interior of the bed.

No. 1703—"*Coal, from Roberts' bank, Troublesome Creek. Sample from the lower part of the bed, called cannel coal. Averaged by P. N. Moore.*"

A pure-looking coal, with but little fibrous coal and no apparent pyrites. Sample somewhat mixed in character. Some pieces of cannel coal; others splint coal; others apparently shaly.

No. 1704—"*Coal, from the same bank. Sample from the middle part of the seam. Called bituminous. Collected by P. N. Moore.*"

Rather a dull-looking coal. Apparently pretty pure, having but little apparent fibrous coal or pyrites between its laminæ. Exterior of some of the lumps covered with ferruginous incrustation.

No. 1705—"*Cannel Coal. Haddock's bed. North Fork of Kentucky river, above the mouth of Troublesome Creek. Collected by P. N. Moore.*"

A very tough coal. Sample somewhat tarnished by weathering, &c., showing ferruginous and clayey incrustation on parts of the surfaces, which may probably make the ash per centage found greater than that of the bed. It has but little fibrous coal, but some evident pyrites.

See volume I, page 354, old series, &c., for other analyses of this coal.

No. 1706—"*Cannel Coal. G. W. Johnson's. Nichol's Fork of Frozen Creek. Sample from near the outcrop. Collected by P. N. Moore.*"

A dull-black coal, very difficult of fracture. Has some little appearance of bright pyrites, and some ferruginous incrustation. No fibrous coal. Some of the seams beautifully polished.

No. 1707—"*Cannel Coal. G. W. Johnson's. Same locality as the preceding. From another outcrop. Sample from hand specimen only.*"

Similar in appearance to the preceding.

No. 1708—*Coal, from Frozen Creek, a quarter of a mile above Wm. Day's. Collected by P. N. Moore.*"

A pure-looking splint coal. Has very little fibrous coal and some little fine granular pyrites between the laminæ; is easily fractured.

No. 1709—"*Cannel Coal. Quicksand Creek. Alfred Little's drift. Collected by John R. Procter.*"

Contains some small bright scales of pyrites. Some portions give an imperfect bird-eye fracture; others show an imperfect fibrous structure, somewhat like that of lignite. Coal generally tough.

No. 1710—"*Coal, from Jackson Wells' bank. Near the mouth of Troublesome Creek. Sample from the outcrop, where the coal is dirty, and hence will give somewhat more than the average ash per centage. Collected by P. N. Moore.*"

A splint coal, with thin partings of fibrous coal containing fine granular pyrites.

No. 1711—"*Cannel Coal, from George's Creek. Collected by P. N. Moore.*"

A pure-looking coal. Has some ferruginous stain on the exterior surfaces, but no apparent pyrites.

No. 1712—"*Coal, from Simon Holland's bank. Collected by P. N. Moore.*"

A pure-looking, splint coal, with not much fibrous coal between the laminæ, and no apparent pyrites. Easily fractured.

No. 1713—"*Coal, from Wolf Creek bank. Collected by J. R. Procter and P. N. Moore. Sample from coal long weathered.*"

A pure-looking, soft splint coal, in thin laminæ, which have quite a glossy cross fracture. Very little fibrous coal or fine granular pyrites between the laminæ.

No. 1714—"*Coal, from William Spencer's mine. North Fork of Kentucky river. Collected by P. N. Moore.*"

A bright, pure-looking coal, showing very little fibrous coal or granular pyrites.

COMPOSITION OF THESE BREATHITT COUNTY COALS, AIR-DRIED.

	No. 1702.	No. 1703.	No. 1704.	No. 1705.	No. 1706.	No. 1707.	No. 1708.	No. 1709.	No. 1710.	No. 1711.	No. 1712.	No. 1713.	No. 1714.
Specific gravity	1.405	1.280	1.290	1.265	1.360	1.180	1.300	1.328	1.398	1.280	1.290	1.290	1.297
Hygroscopic moisture	3.30	3.40	2.20	1.30	1.60	1.20	2.50	2.10	2.78	0.94	4.90	2.76	3.56
Volatile combustible matters	31 44	43.40	39.20	47.00	43.20	58.80	41.10	43.10	35.52	52.38	35.30	36.68	33.56
Coke	65.26	53.20	58.60	51.70	55.20	40.00	56.40	54.80	61.70	46.68	59.80	60.56	62.88
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Total volatile matters	34.74	46.80	41.40	48.30	44.80	60.00	43.60	45.20	38.30	53.32	40.20	39.44	37.12
Fixed carbon in the coke	49.76	46.96	51.14	44.40	33.80	35.30	49.22	43.36	44.94	35.54	55.50	56.50	58.38
Ash	15.50	6.24	7.46	7.30	21.40	4.70	7.18	11.44	16.76	11.14	4.30	4.06	4.50
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Character of the coke	Dense friable.	Friable.	Spongy.	Dense.	Pulverulent.	Dense.	Light spongy.	Spongy.	Dense spongy.	Dense.	Spongy.	Light spongy.	Light spongy.
Color of the ash	Pinkish-grey.	Light buff-grey.	Lilac-grey	Brownish-grey.	Light buff.	Light grey-buff.	Dark lilac.	Light grey	Light lilac-grey.	Light lilac-grey.	Light grey	Light yellowish-grey.	Light lilac-grey.
Per centage of sulphur	0.991	0.630	2.525	1.574	2.549	not est.	0.818	4.609	1.423	1.423	3.153	0.865	1.381

These coals are, generally, superior in quality to the average. Some few of them contain an inordinate proportion of ash; but this will not prevent them from being quite valuable as fuel. The per centage of sulphur in them is generally low. Some, however, exceed somewhat in this respect, especially No. 1712, which contains much more than is indicated by its external appearance, amounting to about three fourths of the weight of the ash—a fact which shows that much of it is in a free state, or in organic combination in the coal.

The usual relationship of specific gravity to ash per centage is shown in these coals, as follows:

Number.	Ash per centage.	Specific gravity.	Number.	Ash per centage.	Specific gravity.
1713	4.00	1.290	1704†	7.46	1.290
1712	4.30	1.290	1711*	11.14	1.280
1714	4.50	1.297	1709*	11.44	1.398
1707*	4.70	1.180	1702	15.50	1.405
1703	6.24	1.280	1710	16.76	1.398
1708	7.18	1.300	1706*	21.40	1.360
1705*	7.30	1.265			

* A cannel coal. † Partly cannel.

The cannel coals are well known to be less dense than the splint and bituminous, and hence show a discrepancy in the comparison instituted. They contain a much larger quantity of hydrogen also, as exhibited in their large proportion of volatile combustible matters, as shown in the above table.

CARTER COUNTY.

No. 1715—"BLOCK ORE. *Joe Harris'. Jordan Branch of Tygert's Creek. Collected by A. R. Crandall.*" *A cabinet specimen.*

A kidney of dark-grey, fine granular iron carbonate, invested with concentric layers of limonite ore (hydrated peroxide) of various tints, from dark-brown to brownish yellow.

The interior and exterior parts were submitted to analysis separately, as were Nos. 1698 and 1699 (which see), for the purpose of studying the causes of the change from carbonate to limonite.

COMPOSITION, DRIED AT 212° F.

	Interior.	Exterior.
Iron carbonate	33.189	. . .
Iron peroxide	5.616	42.548
Alumina and manganese oxide	27.105	22.984
Lime carbonate	12.180	5.180
Magnesia carbonate	1.095	. . . . .
Magnesia	. . . . .	.110
Phosphoric acid	2.060	2.218
Sulphuric acid	a trace.	a trace.
Water and loss	4.375	7.671
Silicious residue	14.380	19.280
Total	100.000	100.000
Per centage of iron	19.953	29.953
Per centage of phosphorus	.899	.968
Per centage of sulphur	a trace.	a trace.
Per centage of silica	14.300	19.280

The relative proportion of iron is notably increased in the limonite; the water, phosphoric acid, and silica are also increased; while the lime, magnesia, and alumina are diminished: indicating, like the previous analyses above referred to, no regular order of change.

PIG IRON OF CARTER COUNTY.

No. 1716—"*Hot-blast Mill Iron, from Mount Savage Furnace. Collected by P. N. Moore.*"

A dark-grey, fine-grained iron. Yields to the file; extends considerably under the hammer.

No. 1717—"*Hot-blast No. 2 Foundry Iron. Mount Savage Furnace. Collected by P. N. Moore.*"

A moderately fine-grained iron. Yields to the file; extends somewhat under the hammer.

No. 1718—"*Hot-blast, Silver-grey Iron, from Mount Savage Furnace. Collected by P. N. Moore.*"

Whiter, coarser grained, and more brittle than the preceding.

COMPOSITION OF THESE MOUNT SAVAGE PIG IRONS.

	No. 1716.	No. 1717.	No. 1718.
Specific gravity	6.930	7.042	7.435
Iron	93.268	91.584	89.687
Graphite	3.950	2.600	2.300
Combined carbon	.770	1.070	.500
Silicon	1.799	3.058	5.575
Slag	.160	.620	.660
Phosphorus	.680	.609	.609
Sulphur	.081	.152	.136
Total	100.708	99.693	99.467
Total carbon	4.720	3.670	2.800

A regular diminution in the proportions of iron and carbon from No. 1716 to 1718, together with a similar increase in the proportions of silicon, slag, and sulphur, as well as of the specific gravity, may be noticed in these samples, corresponding with the quality of the iron. The phosphorus, which is in full average quantity, seems more constant.

CHRISTIAN COUNTY.

COALS.

No. 1719—"*Coal I, from Coalton banks. Sample from the stock pile. Collected by C. J. Norwood.*"

A glossy, black splint coal, breaking into thin laminæ, with very little fibrous coal and some little granular pyrites between them.

No. 1720—"*Coal L, from two miles south of Petersburg. Sampled for analysis by C. J. Norwood.*"

A splint coal, showing fibrous coal and some pyrites. Sample appears to have been weathered.

No. 1721—"*Coal J. At Petersburg Station. St. Louis and Southeastern Railroad. Miners' Coöperation Mine. Average sample by C. J. Norwood.*"

A dull-looking splint coal, but glossy on the cross-fracture of the thin laminæ, between which there is some fibrous coal and granular pyrites.

COMPOSITION OF THESE CHRISTIAN COUNTY COALS, AIR-DRIED.

	No. 1719.	No. 1720.	No. 1721.
Specific gravity	1.307	1.332	1.398
Hygroscopic moisture	4.60	5.10	3.70
Volatile combustible matters	31.94	32.50	32.56
Coke	63.46	62.40	63.74
Total	100.00	100.00	100.00
Total volatile matters	36.54	37.60	36.26
Fixed carbon in the coke	54.36	55.70	50.04
Ash	9.10	6.70	13.70
Total	100.00	100.00	100.00
Character of the coke	Dense.	Very dense	Light spongy.
Color of the ash	Light lilac-grey.	Light lilac-grey.	Greyish-brown.
Per centage of sulphur	1.469	1.277	3.716

MINERAL WATER OF CHRISTIAN COUNTY.

No. 1722—"*Salt Sulphur Water, from a bored well five inches in diameter; bored one hundred and thirty-four feet deep; on the premises of Mr. John B. Trice, Hopkinsville.*" *Bored through solid rock, except through the first sixteen feet.*

The water stands at about one hundred feet higher in the well than the level of the lowest part of the town.

The sample of the water, although brought to the laboratory in a well-corked stone jug, had lost its free hydrosulphuric acid. It smelt slightly sulphurous, and tasted pleasantly saline. It had a light greenish-yellow tint, indicative, probably, of the presence of a little sulphuretted sulphide. It exhibited a slightly alkaline reaction with reddened litmus.

SPECIFIC GRAVITY = 1.005 TO 1.006.

COMPOSITION IN 1000. PARTS.

Lime carbonate	0.1223	Held in solution in the water by carbonic acid.
Magnesia carbonate	.0253	
Iron and manganese carbonates, with a trace of alumina	.0013	
Silica	.0112	
	0.1601	In the sediment formed on boiling.
Sodium chloride	3.3647	
Sodium sulphide	not estimated.	
Soda carbonate	.2366	
Soda sulphate	.5347	
Potassium chloride	a trace.	
Lime sulphate	.1156	
Magnesia sulphate	.4329	
Magnesium iodide	.0018	
Lithia and bromine	marked traces.	
	4.6863	In the boiled water.
Total saline contents	4.8464	In 1000. parts of the water.

The water at the well contains free hydrosulphuric and carbonic acids, the proportions of which can only be found by operation on the freshly drawn water.

The analysis of this water shows it to be quite a good *salt sulphur water*, which may be made available in the treatment of many diseases under proper medical advice.

SOILS OF CHRISTIAN COUNTY.

No. 1723—"*Virgin Soil, from woods adjoining the cultivated field from which the next described soil was taken. Farm of H. C. McCord. Crofton Station. On the flats. Underlying rock sandstone. Collected by C. W. Beckham.*"

Dried soil of an ashy-grey color. It contains a small quantity of shot iron gravel. The silicious residue, after digestion in acids, all passed through bolting-cloth, except a few small angular grains of white and red quartz.

No. 1724—"*Surface Soil, from a field fifteen years in cultivation, adjoining the woodland from which the preceding sample was taken. (Principal crops cultivated, corn and tobacco.) Collected by C. W. Beckham.*"

Dried soil of a brownish-grey color; much darker colored than the preceding. Contains a little iron gravel. Silicious residue contained fewer quartz grains.

No. 1725—"*Subsoil of the next preceding. Collected by C. W. Beckham.*"

Dried soil of a grey-buff color; contains a little iron gravel. Silicious residue like next preceding.

No. 1726—"*Virgin Soil; farm of S. W. Williams. St. Louis and Southeastern Railroad. Petersburg. Forest growth principally oaks. Collected by C. W. Beckham.*"

Dried soil of a light brownish-grey color; contains very little iron gravel. Silicious residue passed through bolting-cloth, except a few fine round grains of clear quartz.

No. 1727—"*Surface Soil, from an old field forty-five years in cultivation in corn and tobacco; on same farm, and about a quarter of a mile distant. Field about thirty feet above the flats. Collected by C. W. Beckham.*"

Dried soil of a grey-buff color; contains no gravel. No quartz grains in the silicious residue.

No. 1728—"*Subsoil of the next preceding,*" *&c.*

Dried soil of a light yellowish-brown color; contains no gravel or quartz grains.

No. 1729—"*Virgin Soil, from the farm of Mr. Durty, near Hopkinsville. Forest growth: cedar, white and red oak, black jack, white walnut, &c. Underlying rock very compact limestone. Collected by C. W. Beckham.*"

Dried soil of a light-greyish color; contains no gravel. The silicious residue passed through bolting-cloth, with the exception of a few small angular quartz grains.

No. 1730—"*Surface Soil, from an old field about fifty years in cultivation in corn, tobacco, and wheat. From the same farm as the next preceding. Collected by C. W. Beckham.*"

Dried soil of a light yellowish-grey-brown color. The bolting-cloth separated but few small angular quartz grains from the silicious residue.

No. 1731—*Subsoil of the next preceding, &c., &c.*

Dried soil of a light brick color. Silicious residue contains a few small angular quartz grains.

No. 1732—"*Virgin Soil; farm of E. F. Kelly. Kelly's Station, on the L. & E. E. Railroad, eight miles north of Hopkinsville. Underlying rock, sandstone. Principal forest growth: white, black, and post oaks and hickory. Collected by C. W. Beckham.*"

Soil of a dirty-buff color. All passed through the coarse sieve, except two small ferruginous concretions. The silicious residue all passed through bolting-cloth, except a few small grains of clear quartz and of reddish silicate.

No. 1733—"*Surface Soil, from a field fifty years in cultivation; principal crops tobacco and corn. From the same farm as the next preceding. Collected by C. W. Beckham.*"

Dried soil of a light grey-brown color; contains no gravel. Silicious residue contains a few more small quartzose grains than preceding.

No. 1734—"*Subsoil of the next preceding. Collected by C. W. Beckham.*"

Dried soil of a dark grey-buff color; contains no gravel and very few fine quartzose grains.

No. 1735—"*Virgin Soil, from woods. Farm of Mr. Campbell, near Hopkinsville. Underlying rock, limestone. Collected by C. W. Beckham.*"

Dried soil of a dirty, dark-grey color; contains no gravel. The silicious residue all passed through the bolting-cloth, except a few quartzose grains, clear and reddish and blackish, and a small silicified entrochite.

No. 1736—"*Surface Soil, from an adjoining field, about forty years in cultivation, in corn and tobacco and meadow. Collected by C. W. Beckham.*"

Dried soil of a light-grey-brown color; contains no gravel. The bolting-cloth separated more fine quartzose and entrochi from the silicious residue than from that of the preceding.

No. 1737—"*Subsoil of the next preceding*," *&c., &c.*

Dried soil of a light brick color; contains no gravel. Silicious residue contains about the same proportion of quartzose grains, &c., as that of the preceding.

	No. 1723	No. 1724	No. 1725	No. 1726	No. 1727	No. 1728	No. 1729	No. 1730	No. 1731	No. 1732	No. 1733	No. 1734	No. 1735	No. 1736	No. 1737
Organic and volatile matters	4.200	4.360	3.135	3.300	4.330	4.065	5.165	4.065	3.600	2.625	2.925	2.775	4.675	3.115	3.500
Alumina and iron and manganese oxides	4.810	6.467	9.310	3.922	6.402	12.155	5.540	4.618	11.193	4.036	5.992	9.052	4.127	5.884	12.727
Lime carbonate	.065	.125	.120	.095	.220	.160	.270	.270	.295	.130	.170	.070	.190	.270	.295
Magnesia	.155	.151	.139	.115	.106	.164	.178	.124	.142	.097	.153	.156	.167	.151	.232
Phosphoric acid	.125	.068	.150	.038	.108	.080	.070	.042	.093	.124	.093	.108	.108	.086	.108
Sulphuric acid	not est.	not est.	not est.	not est.	not est.	not est.	not est.	not est.	not est.	not est.	not est.	not est.	not est.	not est.	not est.
Potash	.135	.176	.083	.121	.247	.637	.385	.256	.457	.121	.125	.174	.260	.210	.707
Soda	....	.261	.116	.172	.153	.084	....	....	....	.125	....	....	....	....	.289
Water expelled at 380° F.	.475	.500	.375	.250	.325	.450	.595	.445	.400	.450	.550	.600	.725	.550	.750
Sand and insoluble silicates	89.940	88.710	86.290	91.850	87.925	81.890	88.615	88.915	83.645	92.625	89.755	86.575	89.765	89.815	81.890
Loss	.095	....	.282	.137	.184	.315	....	1.265	.175	....	.237	.490	....	....	....
Total	100.000	100.818	100.000	100.000	100.000	100.000	100.818	100.000	100.000	100.333	100.000	100.000	100.017	100.081	100.498
Hygroscopic moisture	1.725	1.740	1.900	0.925	1.500	2.800	1.710	1.590	3.000	1.050	1.365	2.165	1.600	1.400	3.135
Potash in the insoluble silicates	0.925	.980	1.131	1.462	1.457	1.367	1.669	1.642	1.516	1.421	1.166	1.368	1.304	1.263	.707
Soda in the insoluble silicates	.434	479	.501	.569	.875	1.044	.478	.605	.662	575	.420	.461	.545	.325	.289
Character of the soil	Virgin soil.	Cultivated field.	Subsoil.	Virgin soil.	Old field soil.	Subsoil.	Virgin soil.	Old field soil.	Subsoil.	Virgin soil.	Old field soil.	Subsoil.	Virgin soil.	Old field soil.	Subsoil.

Several facts may be noticed, in a comparative view of these soils; especially that the soils based on limestone are richer in essential mineral ingredients than those on the sandstone; that the soil on the very compact limestone is not so rich as that on the more friable rock; and that the subsoil, as a general rule, containing more alumina and iron oxide, &c., in proportion to the insoluble silicates, is generally richer in potash, phosphoric acid, and other essential ingredients, than the surface soil. Another fact, very generally to be noticed in the comparative analyses of soils is, that, except in certain anomalous cases, and where a richer subsoil has been mixed with the surface soil by the processes of culture, the old field soil generally exhibits, in its analysis, a diminution of the proportions of the essential mineral ingredients, as well as of organic and volatile matters, and an increase of the proportion of sand and insoluble silicates.

CLAY COUNTY.

SALT WATER.

No. 1738—"*Salt water, from Goose Creek Salt-works, as it is pumped from the well. Sent by General T. T. Garrard, of Manchester.*"

The water came in a stone-ware jug, which was stopped with a corn-cob. It was slightly turbid or opaleseent, probably because of the escape of some of its carbonic acid, and the consequent precipitation of part of its earthy carbonates, &c.

COMPOSITION IN 1000. PARTS.

SPECIFIC GRAVITY = 1.065.

Lime carbonate	0.0048	Held in solution by carbonic acid, and precipitated on boiling the water.
Magnesia carbonate	a trace.	
Iron and manganese carbonates	.0038	
Alumina, phosphoric acid, and silica	.0140	
Sodium chloride (common salt)	65.0000	
Calcium chloride	18.8960	
Magnesium chloride	5.0080	
Barium chloride	.3930	
Strontium chloride	.0843	
Lithium chloride	a trace.	
Potassium chloride	a trace.	
Iodine and bromine	a trace.	
Total saline matters (dried at 212°)	**89.4039**	**In 1000. parts of the water.**

A remarkable circumstance is the existence, in this Goose creek brine, of notable quantities of barium and strontium chlorides. The former salt is present in quantity equal to nearly twenty-three grains to the wine gallon of the water, and the latter in the proportion of nearly five grains. As it is well known that the soluble salts of barium exert an injurious influence on the animal economy, it is important that this should be removed in the manufacture of the salt. It is fortunate that this may be very easily and economically done by the addition of sulphate of soda, Glauber's salt, which, added in the quantity of about forty-five to fifty grains of this crystalline salt to the gallon of the fresh brine, will completely precipitate all the barium and strontium in the form of insoluble sulphates, and doubtless also aid in the clarification of the brine.

The cheap salt, sulphate of alumina, in equivalent quantity, would produce the same effect, and perhaps aid more completely in the clarification. Soda ash, carbonate of soda, would be equally effectual.

Barium and strontium salts are also present in the brine of the Glenfont Salt-works of Meade county, but in somewhat smaller proportions. Of course, where these salts are present we find no sulphates in the water.

No. 1739—"*The Bittern Water, left after graining the salt.*" *Goose Creek Salt-works.*

COMPOSITION IN 1000. PARTS.

SPECIFIC GRAVITY = 1.309.

Calcium chloride	350.49
Magnesium chloride	92.38
Sodium, potassium, and lithium chlorides	24.53
Barium and strontium chlorides	not est.
Sodium bromide	5.27
Sodium iodide	not est.

Various useful applications have been made of the bittern water of Salt-works; as in the preparation of bromine and the manufacture of artificial stone. Doubtless it might also be

used (if, like this, it contains much calcium chloride) in setting free the alkalies, contained in the form of insoluble silicates, in some of our marls and clays of the character of the Leitchfield marls. This may probably be done by mixing the marl with a considerable quantity of lime or powdered limestone, making the mixture up into a plastic mass, with the bittern water sufficiently concentrated by evaporation, and then calcining, at a low red heat, the properly prepared lumps or bricks of the mixed materials. These lumps or bricks, if properly calcined, will slack into a crumbling mass when exposed to moisture, in which the alkaline ingredients will be in a soluble condition, available for plant nourishment.

No. 1740—"*The deep-brownish or Spanish-brown colored deposit adhering to the interior of the wooden tube (or "gum") which conducts the brine from the well to the pans. Goose Creek Salt-works.*"

COMPOSITION, DRIED AT 212° F.

Iron peroxide	74.304
Alumina, phosphoric acid, &c.	7.016
Lime carbonate	.280
Magnesia carbonate	.680
Silicious residue	6.890
Saline matters and loss	10.830
Total	100.000

CLINTON COUNTY.

No. 1741—"MARLY CLAY. *Cumberland City mines. Chester Group. (Leitchfield marls.) Collected by N. S. Shaler.*"

A dull olive-grey, indurated marly clay.

COMPOSITION, DRIED AT 212° F.

Silica	70.800
Alumina, with a little iron and manganese oxides and phosphoric acid	18.840
Lime	*.594
Magnesia	4.358
Phosphoric acid	not est.
Sulphuric acid	not est.
Potash	4.240
Soda	.794
Total	99.626

*Equal to 1.060 per cent. of lime carbonate.

(See Grayson county in this and the preceding Chemical Report for similar marls.)

No. 1742—"COAL, *from the Cumberland mines. Conglomerate main coal. Collected by N. S. Shaler.*"

A pure-looking, pitch-black coal, with very little fibrous coal or pyrites.

SPECIFIC GRAVITY = 1.329.

COMPOSITION, AIR-DRIED.

Hygroscopic moisture	1.56
Volatile combustible matters	37.74
Coke	60.70
Total	100.00
Total volatile matters	39.30
Carbon in the coke	50.20
Ash	10.50
Total	100.00
Character of the coke	Light spongy.
Color of the ash	Light lilac-grey.
Per centage of sulphur	2.911

DAVIESS COUNTY.

MINERAL WATERS OF DAVIESS COUNTY.

No. 1743—"*Chalybeate Water, from Murray's Spring, near Lewis. (E., O. & N. R. R.) Collected by Capt. R. S. Triplett.*"

It came to hand in a stone-ware jug, stopped with a corn-cob, which may have somewhat altered the character of the water. The reaction of the water is neutral. No effort was made to estimate its gases.

COMPOSITION IN 1000. PARTS OF THE WATER.

Lime carbonate	0.1155	Held in solution in the water by carbonic acid, and precipitated on boiling.
Magnesia carbonate	.0046	
Iron carbonate	.0229	
Alumina	.0027	
Phosphoric acid	.0004	
Silica	.0107	
Lime sulphate	.0204	
Magnesia sulphate	.0768	
Potash sulphate	.0403	
Soda sulphate	.0476	
Sodium chloride	.0146	
Lithium chloride	.0013	
Silica, &c.	.0142	
Total saline matters	0.3720	Dried at 212° F.

It is doubtless a valuable saline chalybeate water.

MINERAL WATERS *from Dr. Hickman's Springs. Crow's Station (E., O. & N. R. R.). Coal measures. Daviess county. Collected by C. J. Norwood, as follows:*

No. 1744—"*Alum Spring*" (*labeled No.* 1).

This water has a brownish color and a strong acid reaction. The cork of the jug was blackened by the presence of iron salt.

No. 1745—"*Alum Spring*" (*labeled No.* 2).

This water resembles the preceding, but is of a lighter color.

No. 1746—"*Alum Spring*" (*labeled No.* 6). "*Sweet Spring.*"

Resembles No. 2 in the appearance of the water.

No. 1747—"*Sulphur Spring*" (*labeled No.* 3).

Reaction neutral. Has no peculiar taste or smell, having lost all its sulphuretted hydrogen gas.

No. 1748—"*Brick Spring*" (*labeled No.* 4).

Resembles the next preceding.

No. 1749—"*Yellow Spring*" (*labeled No.* 5).

The water has a slightly astringent taste; no color. In reaction is neutral.

All the alum waters deposited a brownish ochreous sediment on standing, which is mainly basic persulphate of iron, as shown by the following analysis (made by my son, Alfred Meredith Peter, who also made the analyses of the several waters, under my general supervision), as follows:

One thousand parts of the water. No. 1 (*i. e.*, No. 1744) gave on boiling 0.1938 part of brownish precipitate, dried at 212°, which became bright red on ignition, and had the following described

COMPOSITION, DRIED AT 212° F.

Iron peroxide	78.64
Combined water	14.74
Sulphuric acid (anhydride)	5.24
Silica	.64
Loss	.74
Total	100.00

COMPOSITION OF THE ALUM WATERS IN 1000. PARTS.

	No. 1744[1]	No. 1745[2]	No. 1746[6]
Basic iron persulphate (Fe_2O_3, $2SO_3$)	0.8756	0.0484	0.1460
Alumina sulphate	1.2468	.3303	.3500
Manganese sulphate	.0032	.0102	.0721
Lime sulphate	.5996	.3947	.3271
Magnesia sulphate	.3330	.3315	.2513
Potash sulphate	.0005	.0068	.0074
Soda sulphate	.0724	.2959	. . . . .
Copper sulphate	.0009	. . . . .	. . . . .
Sodium chloride	.0031	.0127	.0651
Lithia	a trace.	a trace.	a trace.
Silica	.0013	.0014	.0022
Organic matters and loss	. . . . .	.0279	.1878
Total saline matters, dried at 212° F.	3.1364	1.4598	1.4090
Specific gravity of the water	1.00304	1.00164	1.00162

COMPOSITION OF THE "SULPHUR," "BRICK," AND "YELLOW" SPRING WATERS IN 1000. PARTS.

	No. 1747(3)	No. 1748(4)	No. 1749(5)
Iron and manganese oxides	traces.	0.0004	0.0018
Lime carbonate	0.1106	.1196	.0256
Magnesia carbonate	.0196	.0331	.0211
Lime sulphate	.1306	.0838	.1379
Magnesia sulphate	.1594	.1057	.0651
Potash sulphate	.0035	.0129	.0103
Soda sulphate	.4567	.5019	.2082
Sodium chloride	.0809	.0213	.0127
Lithia	traces.	traces.	traces.
Copper	.....	.....	a trace.
Silica	.0174	.0254	.0298
Organic matters and loss	.0373	.....	.0357
Total saline matters, dried at 212° F.	1.0160	0.9041	0.5482
Specific gravity of the water	1.00115	1.00120	1.00086

These alum waters, doubtless of analogous composition with others of the name in Virginia and elsewhere, are highly astringent, and are doubtless too strong for internal use without dilution, in most cases. They will find their remedial applications, however, under the advice of the educated physician. The saline and sulphur waters would prove alterative, slightly aperient, diuretic, or sudorific and hence depurative, according to the manner of their administration, under medical advice. The small amount of copper in the alum waters will not materially affect their influence.

SOILS OF DAVIESS COUNTY.

No. 1750—"*Virgin Soil, from the farm of H. Riley, on the E., O. & N. R. R., fifteen miles from Owensboro. On a hill-top. Collected by C. W. Beckham.*"

Soil of a light grey-brown color; contains no gravel. The bolting-cloth sieve separated from its silicious residue a considerable quantity of fine, rounded quartz grains, both hyaline and opaque.

No. 1751—"*Surface soil, from an old field sixty-five years in cultivation, in corn and tobacco principally; now overgrown with sassafras. Same locality as the preceding. Collected by C. W. Beckham.*"

Soil of a lighter and more yellowish light-grey-brown color; has no gravel. Silicious residue contained very few small quartz grains.

No. 1752—"*Subsoil to the next preceding*," *&c., &c.*

Soil of a brownish-yellow ochre color; contains no gravel. Very few fine quartz grains.

No. 1753—"*Virgin Soil. Upland. From the farm of the Rev. A. Hopkins. Crow's Station, E., O. & N. R. R., nine miles from Owensboro. Collected by C. W. Beckham.*" *Coal measures.*

Soil of a brownish umber-grey color; contains no gravel nor fine quartz grains.

No. 1754—"*Surface Soil, from an old field about forty years in cultivation. Same locality as preceding. Substratum; sandstone. Collected by C. W. Beckham.*"

Soil of a dirty buff color; contains no gravel or fine silicious sand.

No. 1755—"*Subsoil of the next preceding*," *&c. &c.*

Soil of a brownish-orange-buff color; contains no gravel or fine quartzose sand.

COMPOSITION OF THESE DAVIESS COUNTY SOILS, DRIED AT 212° F.

	No. 1750	No. 1751	No. 1752	No. 1753	No. 1754	No. 1755
Organic and volatile matters. . .	5.475	3.150	2.715	5.875	2.550	3.175
Alumi'a and iron and mang. oxides	6.174	7.065	10.654	5.349	5.502	12.958
Lime carbonate	.120	.245	.095	.220	.085	.075
Magnesia	.016	.034	.021	.044	.133	.080
Phosphoric acid	.141	.125	.061	.086	.083	.102
Sulphuric acid	not est.	not est.	not est.	not est.	not est.	not est.
Potash	.134	.053	.244	.407	.265	.474
Soda	.301	. . . .	. . . .	. . . .	. . . .	.075
Sand and insoluble silicates . . .	86.605	88.390	85.415	86.590	90.890	81.300
Water expelled at 380° F.	.975	.925	.910	1.450	.600	1.175
Total	99.941	99.987	100.115	100.021	100.108	99.414
Hygroscopic moisture.	1.775	1.515	1.565	1.700	0.875	3.500
Potash in the insoluble silicates .	.887	1.122	1.386	.975	1.396	1.457
Soda in the insoluble silicates . .	.581	.709	.680	.403	.729	.639
Character of the soil	Virgin soil.	Old field soil.	Subsoil.	Virgin soil.	Old field soil.	Subsoil.

The comparative analyses of these soils show the usual influence of continued exhaustive culture in the diminution of some of their essential mineral ingredients. The soils are of full average natural fertility; the subsoils would doubtless benefit the surface, if gradually brought up in the cultivation, and organic matters supplied by the ameliorating influence of clover and other green crops wholly or partly plowed in. A considerable reserve of the alkalies is seen to be present in the insoluble silicates, which will add greatly to the durability of the soil; but, doubtless, the application of available phosphates, and the use of wood ashes, would be beneficial in increasing the productiveness of the old field soils.

No. 1756—"CLAY, *from the same locality; twenty feet from the railroad and ten feet below the surface of soil No.* 1754. *Below the coal at Dr. Hickman's Springs. The layer is about thirteen inches thick.*"

A sandy clay; generally of a light-grey color, with ferruginous infiltrations in the fissures, and some old obscure vegetable impressions. It contains about fifty per cent. of fine clear sand. It burns quite hard, and of a handsome light-salmon color, and hence may be quite valuable for *terra cotta* work or bricks or tiles.

The air-dried clay lost 1.500 per cent. of moisture at 212° F.; .005 per cent. of moisture at 380°, and 1.500 per cent. of combined water at the red heat. It would probably shrink less in the fire than most clays, but would not answer for a fire-clay.

COALS OF DAVIESS COUNTY.

No. 1757—"*Coal No. D? Montgomery's coal mine, about one and a half miles above Owensboro. Collected by C. J. Norwood.*"

A pure pitch-black coal. Has but little fibrous coal. Some thin scales of pyrites in the seams.

No. 1758—"*Coal D. Dutch mine, about one and a half miles above Owensboro. Average thickness about three feet. Average sample by C. J. Norwood.*"

A splint coal; some reedy fibrous coal between the laminæ, and much show of bright pyritous scales in the seams.

No. 1759—"*Coal D. Bon Harbor mines. Barrett's new bank. Average thickness four feet and a half. Sample by C. J. Norwood.*"

A splint coal, with much fibrous coal between the laminæ, and granular and bright lamellar pyrites. Iridescent on some of the seam faces.

No. 1760—"*Coal D. Dean's mine, about one and a half miles above Owensboro. Collected by C. J. Norwood.*"

Resembles the preceding.

No. 1761—"*Coal, from Duncan's bank. Richardson's property. Friendly Grove, near Knottsville. Collected by P. N. Moore.*"

Mostly splitting easily into thin laminæ, with considerable fibrous coal and some granular pyrites between. Some bright scales of pyrites in the seams.

COMPOSITION OF THESE DAVIESS COUNTY COALS, AIR-DRIED.

	No. 1757.	No. 1758.	No. 1759.	No. 1760.	No. 1761.
Specific gravity	1.323	1.340	1.318	1.337	1.285
Hygroscopic moisture	6.20	4.10	5.80	5.12	6.20
Volatile combustible matters	36.20	38.50	35.06	34.72	41.90
Coke	57.60	57.40	59.14	60.16	51.90
Total	100.00	100.00	100.00	100.00	100.00
Total volatile matters	42.40	42.60	40.86	39.84	48.10
Carbon in the coke	50.90	51.00	50.40	51.44	47.40
Ash	6.70	6.40	8.74	8.72	4.50
Total	100.00	100.00	100.00	100.00	100.00
Character of the coke	Light spongy.	Spongy.	Light spongy.	Light spongy.	Light spongy.
Color of the ash	Lilac-grey.	Lilac-grey.	Light lilac-grey.	Light lilac-grey.	Grey-lilac.
Per centage of sulphur	1.519	1.538	3.985	3.513	3.743

EDMONSON COUNTY.

LIMONITE IRON ORES.

No. 1762—"*Ore, from Still-house Branch of Bear Creek. Average sample by P. N. Moore.*"

In irregular curved laminæ, of a deep brown color; frequently inclosing nuclei of softer yellowish and reddish ochreous ore.

No. 1763—"*Ore, from the south side of Dismal Creek, near Thomas Meredith's. Average sample by P. N. Moore.*"

Mostly in dense dark brown irregular curved laminæ, with some softer and lighter colored ore.

No. 1764—"*Ore, from the head of Sycamore Branch of Bear Creek. Average sample by P. N. Moore.*"

Much like the preceding.

No. 1765—"*Ore above the coal. Mill Branch of Bear Creek. Average sample by P. N. Moore.*"

In thin irregular laminæ, cellular in parts, of a brown color; mixed with yellowish-brown ochreous ore.

No. 1766—"*Limestone Ore. Jacob Snider's. Cane Branch of Gulf Creek. In the Chester Group. Cabinet specimen. Collected by P. N. Moore.*"

Mostly dense dark-colored ore, in carved laminæ or cellular masses, with some little brownish-ochreous softer ore.

COMPOSITION OF THESE EDMONSON COUNTY LIMONITE ORES, DRIED AT 212° F.

	No. 1762.	No. 1763.	No. 1764.	No. 1765.	No. 1766.
Iron peroxide	40.798	47.724	49.906	32.820	77.871
Alumina	.....	.....	.....	.....	1.444
Manganese oxide	1.293	2.501	3.330	2.356	not est.
Lime carbonate	a trace.	a trace.	a trace.	a trace.	a trace.
Magnesia	a trace.	a trace.	a trace.	a trace.	.070
Phosphoric acid	1.019	.697	.694	.984	.505
Sulphuric acid	.360	.315	.395	.285	a trace.
Combined water	7.250	8.256	9.320	8.330	11.050
Silica and insoluble silicates	50.030	41.145	36.780	55.180	8.660
Moisture and loss	.....	.....	.....	.045	.400
Total	100.750	100.632	100.425	100.000	100.000
Per centage of iron	28.559	33.407	34.407	22.974	54.510
Per centage of phosphorus	.445	.304	.303	.430	.221
Per centage of sulphur	.207	.125	.158	.114	a trace.
Per centage of silica	46.760	39.560	33.460	48.960	8.660

With the exception of No. 1766, which is quite good and rich, these are rather poor, highly silicious ores, with a full amount of phosphorus, which might be profitably used with richer aluminous ores.

EDMONSON COUNTY CLAYS.

No. 1767—"*Silicious Clay, from Sowder's farm, near Green river. Chester Group. Bed four to six feet thick. Collected by John R. Procter.*"

In irregular lumps; friable; of an olive and brownish-grey color. Powder light grey.

No. 1768—"*Clay, from Sowder's farm, on Caney Branch, one mile from Green river. Bed seven to eight feet thick; in layers of various colors. Collected by John R. Procter.*"

(*a*) The upper or light-dove-colored layer.

(*b*) The second, light grey, nearly white layer.

(*c*) The third, grey layer.

(*d*) The lowest layer. Olive-grey, mottled with yellowish-grey.

COMPOSITION OF THESE EDMONSON COUNTY CLAYS, DRIED AT 212° F.

	No. 1767.	No. 1768 *a*.	No. 1768 *b*.	No. 1768 *c*.	No. 1768 *d*.
Silica	80.160	77.660	74.460	71.560	67.560
Alum'a and iron and mang. ox's	11.600	16.800	20.440	22.860	22.540
Lime carbonate	.760	.480	.640	.680	.980
Magnesia	.560	not est.	not est.	not est.	.671
Phosphoric acid	not est.	not est.	not est.	not est.	.025
Potash	3.854	1.002	not est.	not est.	2.470
Soda	.583	.484	not est.	not est.	.058
Water and undetermined	2.483	4.340	4.460	4.900	5.696
Total	100.000	100.766	100.000	100.000	100.000

While these clays would not prove very refractory in the fire, they may be made very useful for common pottery ware.

ESTILL COUNTY.

No. 1769—CLAY IRON-STONE. "*Carbonate ore, from Tubb's bank, near Estill Furnace. Has been weathered two years. Collected by P. N. Moore.*"

A granular carbonate ore, of various tints of grey, with more or less of limonite. In some parts somewhat oölitic.

COMPOSITION, DRIED AT 212° F.

Iron carbonate	76.491	= 39.758 per cent. of iron.
Iron peroxide	4.049	
Alumina	2.014	
Manganese carbonate	not est.	
Lime carbonate	5.400	
Magnesia carbonate	.514	
Phosphoric acid	.409	= 0.178 phosphorus.
Sulphuric acid	.267	= .107 sulphur.
Silicious residue	9.330	Containing 7.660 silica.
Undetermined and loss	1.526	
	100.000	

Quite a good ore of its kind.

ESTILL COUNTY LIMONITE ORES.

No. 1770—"*Ore, from Luster drift. Thacker Ridge. Railroad west of Fitchburg. Sample has been exposed to the weather for some time. Collected by P. N. Moore.*"

In irregular, dense, dark-colored, curved laminæ, with some soft ochreous ore between.

No. 1771—"*Limestone Ore. Logan Ridge. Estill Furnace. Has been weathered two years. Collected by P. N. Moore.*"

Resembles the preceding. Ochreous matter brownish.

No. 1772—"*Ore, from Tubb's bank. Estill Furnace. Has been weathered two years. Collected by P. N. Moore.*"

Resembles the preceding.

No. 1773—"*Ore, from Horse-ridge banks. Cottage Furnace. In sub-carboniferous limestone. Average sample from a pile of ore weathered more than a year. Collected by P. N. Moore.*"

Mostly in dense, dark-colored laminæ, irregularly curved or forming a cellular structure, with some whitish and light-brown softer material.

COMPOSITION OF THESE ESTILL COUNTY LIMONITES, DRIED AT 212° F.

	No. 1770.	No. 1771.	No. 1772.	No. 1773.
Iron peroxide	74.127	65.535	75.598	65.591
Alumina	3.542	2.798	1.971	5.762
Manganese oxide	not est.	not est.	not est.	not est.
Lime carbonate	.390	.450	.540	traces.
Magnesia	.461	1.073	.258	.248
Phosphoric acid	.601	.537	.601	.447
Sulphuric acid	not est.	not est.	not est.	traces.
Combined water	11.270	9.800	11.730	11.000
Silica and silicates	9.580	20.480	8.910	16.230
Moisture and loss	.029	. . . . .	.392	.722
Total	100.000	100.673	100.000	100.000
Iron per centage	51.889	45.874	52.918	45.914
Phosphorus per centage	.262	.234	.262	.195
Sulphur per centage	not est.	not est.	not est.	traces.
Silica per centage	7.860	18.260	7.260	14.160

PIG IRONS OF ESTILL COUNTY.

No. 1774—"*No. 3 Cold-blast Charcoal Pig Iron. Red River Furnace. Fitchburg. Collected by P. N. Moore.*"

A moderately fine-grained, somewhat dark-colored iron. Yields to the file and extends a little under the hammer.

No. 1775—"*No.* 5 *Cold-blast Charcoal Pig Iron. Red River Furnace, &c. Collected by P. N. Moore.*"

A silvery-white iron. Hard, brittle; but the small fragments extend a little under the hammer.

No. 1776—"*Car-wheel Iron. No.* 1 *Cold-blast Charcoal Iron. Red River Iron Works, at Fitchburg. From G. S. Moore & Co., of Louisville.*"

A moderately coarse-grained, dark-grey iron. Yields with difficulty to the file; extends somewhat under the hammer.

No. 1777—"*Car-wheel Iron. No.* 1 *Cold-blast Charcoal Iron. Estill Furnace. From G. S. Moore & Co.*"

Resembles the preceding, but is somewhat coarser-grained, with some spots of finer-grained in the centre of the pig.

COMPOSITION OF THESE ESTILL FURNACE IRONS.

	No. 1774.	No. 1775.	No. 1776.	No. 1777.
Iron	93.728	93.963	94.174	92.582
Graphite	3.520	2.000	3.340	3.500
Combined carbon	.780	2.550	1.110	1.200
Manganese	.389	.181	not est.	not est.
Silicon	1.202	.363	.447	.960
Slag	.360	.320	.360	.360
Aluminum	.264	.648	not est.	not est.
Phosphorus	.290	.338	.402	.444
Sulphur	.080	.104	.182	.066
Undetermined and loss	.....	.....	.....	.888
Total	100.613	100.467	100.015	100.000
Total carbon	4.300	4.550	4.450	4.700
Specific gravity	7.168	not est.	7.226	7.272

The high character of these pig metals for producing tough malleable iron is well established.

FAYETTE COUNTY.

No. 1778—"PHOSPHATIC LIMESTONE. *Forming a thin layer in the Lower Silurian (Blue) limestone (Cincinnati Group?). McMeekin's quarry. Newtown Turnpike, about three miles north of Lexington. Said by the quarryman to be sometimes as much as a foot in thickness. Collected by R. Peter.*"

A somewhat friable rock of a bluish-grey color; brownish-grey on the weathered surfaces. Containing many microscopic marine univalve shells. Adheres strongly to the tongue.

COMPOSITION, DRIED AT 212° F.

Phosphoric acid, lime, magnesia, alumina, iron oxide	85.270
Fluoride of calcium	not est.
Carbonate of lime	9.180
Carbonate of magnesia	.371
Silica and insoluble silicates	4.780
Alkalies, organic matters, &c., not estimated	.399
Total	100.000

The phosphates in this limestone were found to contain as much as 31.815 per cent. of the weight of the rock of phosphoric acid, equal to 69.452 per cent. of tribasic phosphate of lime!

This remarkable rock, on a pile thrown out for turnpiking purposes, attracted the attention of the writer, while riding along the road. Although it has been long known that the friable layers of our "Blue limestone" are quite rich in phosphates, a fact which the writer brought to the attention of the agricultural public as early as April, 1849, in the Albany Cultivator, of New York, yet no one up to this time, as far as is known to him, has found any so rich in them as this.

The subject is worthy of further investigation, especially in view of the agricultural and commercial value of the phosphates for use as fertilizers. As is well known, the abundant phosphates of the rock substratum is one of the main causes of the great and durable fertility of our "blue grass soil," so-called, as well as of the superior development of the animals reared and nourished on its products.

SOILS OF FAYETTE COUNTY.

No. 1779—"*Virgin Soil, taken from one half inch to six inches below the surface. From woodland pasture, which has been grazed for about seventy years. On elevated ground, near the remains of the old earth-works of the mound-builders. (Described in Collins' History of Kentucky and elsewhere as on*

the farm of Col. Meridith, who was the earliest proprietor of the farm.) On the farm of R. Peter. Same as described in No. 27 in volume I, old series, Kentucky Geological Reports. On the Lower Silurian formation. Collected by B. D. Peter."

A rich grey-brown loam, containing a little fine-grained shot iron ore, and some small silicious particles. The bolting-cloth separated from the insoluble silicates, left after digestion of the soil in acids, a small portion of small roundish-whitish grains of partly decomposed silicates, but no pure quartz grains.

No. 1780—"*Subsoil of the preceding, taken from six to fourteen inches below the surface.*"

Soil rather more reddish than the surface soil. Contains, like that, a few small grains of shot iron ore and silicious particles. The bolting-cloth separated a rather larger quantity of small rounded grains of undecomposed silicates; some appearing as casts of minute globular shells.

No. 1781—"*Virgin Soil. Open pasture. J. H. Talbutt's farm* ("*The Meadows*"), *late Warfields; half a mile northeast of Lexington. From the top of a hill to the east of the house, heavily set with blue grass. Sample taken to the depth of sixteen inches. Primitive growth: black walnut, black, blue, and white ash, elm, hickories, oaks, sugar-tree, &c. Has been long cleared. Lower Silurian formation. Sample collected by John H. Talbutt.*"

Dried soil of an umber color; contains no gravel, but some little shot iron ore, &c.

No. 1782—"*Subsoil of the next preceding; taken to the depth of three feet from the surface,*" *&c., &c.*

No. 1783—"*Underlying clay of the same; taken at the depth of three feet below the surface. Contains shot iron ore, manganese oxide,*" *&c.*

Dried subsoil of a dirty light-brown color. The silicious residue contained a few small quartzose grains.

COMPOSITION OF THESE FAYETTE COUNTY SOILS, DRIED AT 212° F.

	No. 1779.	No. 1780.	No. 1781.	No. 1782.	No. 1783.
Organic and volatile matters . .	4.676	3.085	7.800	4.410	4.400
Alum'a and iron and mang. ox's	9.570	*10.445	12.286	14.427	19.921
Lime carbonate.	.230	.220	1.145	.545	.130
Magnesia	.140	.140	.394	.340	.376
Phosphoric acid	.444	.540	.364	.358	.364
Sulphuric acid	not est.	not est.	not est.	not est.	not est.
Potash	.287	.343	.735	.402	.755
Soda.	not est.	.192	.084	.301	. . . . .
Sand and insoluble silicates . .	82.860	83.260	76.690	77.440	72.540
Water, expelled at 380° F.. . .	1.824	1.234	1.300	.925	1.200
Undetermined and loss	. . . . .	.541	. . . . .	.852	.314
Total	100.031	100.000	100.798	100.000	100.000
Hygroscopic moisture	2.165	1.965	2.975	3.135	3.525
Potash in the insoluble silicates.	1.274	1.314	.718	.910	.644
Soda in the insoluble silicates .	.211	.583	.200	.212	.167
Character of the soil	Woodland pasture.	Subsoil.	Virgin soil.	Subsoil.	Under clay.

*Containing: of alumina, 6.093; iron peroxide, 4.330; and manganese oxide, .020 per cent.

The analyses demonstrate the richness of these soils, more especially of Nos. 1781–'2–'3, which is shown in the small relative quantity of silicious residue, and the comparatively large proportions of phosphoric acid and potash, &c. Although they may not have been submitted to the plow, they yet cannot be considered virgin soils, having been for a long time grazed, and been thus altered in composition. The "Meadows" has been mostly cultivated as a stock farm, mainly for the raising of fine race-horses and improved cattle; and there is reason to believe, from the large proportion of potash in the soluble form in this pasture land, that it was improved rather than deteriorated by the feeding of the stock upon it: the loss by grazing being more than compensated by the additional food supplied to the animals, in winter as well as other times.

FLOYD COUNTY.

COALS.

No. 1784—"*Coal. Snipe's bank. Branch of Abbott's Creek. Average sample from the outcrop. About two feet shown. Collected by A. R. Crandall.*"

A pretty pure splint coal. Some fibrous coal and fine granular pyrites between the laminæ, and some external ferruginous stain.

No. 1785—"*Coal, from Harris' bank, on Muddy Creek, one mile from Prestonsburg. Forty-four inches thick. Average sample by A. R. Crandall.*"

A bright, pitch-black coal, with some bright pyritous scales, and but little fibrous coal. A somewhat hard coal.

No. 1786—"*Coal. Jas. H. Hatcher's bank. Mouth of Abbott's Creek. Bed forty-two to forty-six inches thick. Average sample by A. R. Crandall.*"

A bright-looking, somewhat firm coal, with very little fibrous coal or pyrites.

COMPOSITION OF THESE FLOYD COUNTY COALS, AIR-DRIED.

	No. 1784.	No. 1785.	No. 1786.
Specific gravity	1.289	1.274	1.307
Hygroscopic moisture	3.20	2.50	2.50
Volatile combustible matters	38.80	40.80	38.56
Coke	58.00	56.70	58.94
Total	100.00	100.00	100.00
Total volatile matters	42.00	41.30	41.06
Fixed carbon in the coke	55.04	56.70	53.44
Ash	2.96	3.24	5.50
Total	100.00	100.00	100.00
Character of the coke	Light spongy.	Spongy.	Light spongy.
Color of the ash	Light chocolate.	Light brownish.	Light lilac-grey.
Percentage of sulphur	1.289	1.895	1.915

These are all remarkably pure and good coals. Their small ash per centage corresponds nearly with their low specific

gravity. Their proportion of sulphur is also moderate. Their large yield of volatile combustible matters, and their spongy coke, may make them profitably available for use in the gas-works. Doubtless they will be found very good for the smelting and manufacture of iron.

GRAYSON COUNTY.

COAL.

No. 1787—"*Coal, from the South or Allen bank, near the Falls of Rough Creek. Two feet thick. Collected by P. N. Moore.*"

A pure-looking coal, breaking easily, with a shining pitch-like appearance, and an irregular, so-called, bird's-eye fracture. Has very little fibrous coal and no apparent pyrites, except some fine granular.

COMPOSITION, AIR-DRIED.

Specific gravity	1.343		
Hygroscopic moisture	6.50	Total volatile matters	36.54
Volatile combustible matters	30.04		
Coke (quite dense)	63.46	Carbon in the coke	55.54
		Light lilac-grey ash	7.92
	100.00		100.00
Per centage of sulphur	1.972		

FERRUGINOUS AND MARLY CLAYS OF GRAYSON COUNTY.

No. 1788—"*Ferruginous Clay. Nodular. Below the upper limestone. Hat Branch of Bear Creek. Three and a half to four feet thick.*"

Of a handsome chocolate-brown color. Not adhering much to the tongue. Powder of a handsome grey-chocolate color.

No. 1789—"*Nodular Ferruginous Clay. Canolaway Creek.*"

Resembles the preceding.

No. 1790—"*Marly Shale, found below the limestone. Hat Branch of Bear Creek. Four feet thick. Collected by John R. Procter.*"

Breaking easily when dry. Of a greyish-olive-green color, with some parts brownish. Not adhering much to the tongue. Powder of a handsome greenish-grey color.

No. 1791—"*Marly Shale. Haycraft's Lick. Similar to preceding.*"

Of a dark olive-grey color when dry.

No. 1792—"*Red Marly Shale, same locality, &c., mixed with the preceding in the sample.*"

Of a chocolate brown color.

No. 1793—"*Brown Marly Clay. Cedar Knob Lick.*"

Of a dark reddish-brown or chocolate color when dry. Conglomeratic, with fragment of material similar to No. 1792.

COMPOSITION OF THESE GRAYSON COUNTY FERRUGINOUS AND MARLY CLAYS AND SHALES, DRIED AT 212° F.

	No. 1788.	No. 1789.	No. 1790	No. 1791	No. 1792	No. 1793
Alumina . . . . . } Iron and manganese oxides }	14.451	*b*12.282 } *c*7.588 }	26.221	27.811	25.758	23.071
Lime carbonate	1.160	1.380	9.160	.880	1.580	1.180
Magnesia	1.715	1.643	6.629	.824	4.437	.497
Phosphoric acid	1.089	see *b*.	1.089	.109	.102	.089
Potash } Total, obtained by fusion;	4.240	5.049	4.944	5.554	5.145	4.093
Soda } includes insoluble silicates.	.948	1.060	1.061	.657	.347	.438
Silica and insoluble silicates .	74.360	*d*68.380	44.760	59.920	58.960	60.760
Water expelled at red heat, &c.	7.000	8.250	6.136	4.245	3.671	9.872
Total	*a*104.963	*a*105.632	100.000	100.000	100.000	100.000

(*a*) The apparent excess is due to the alkalies in the insoluble silicates, which are estimated also in the *total* alkalies given above.
(*b*) Including phosphoric acid and manganese oxide, not separately estimated.
(*c*) Iron peroxide.
(*d*) Containing of silica: 51.020; of alumina, iron and manganese oxides, and phosphoric acid, 14.330.

These ferruginous and marly shales and clays, when of a good color, may be termed mineral paints, and be very profitably used in that way; but, in consequence of their large proportions of alkalies, especially of potash, as well as of phosphoric acid, they promise to be quite valuable, applied as top dressing, for renewing old worn-out tobacco soil. As they are found in enormous quantities over a very great extent of country, the best method of making them profitably available is matter of great interest.

Chemical analyses show that, while a portion of their alkaline constituents is soluble in acids, the larger part of them is locked up in the insoluble silicates. Spread upon the soil,

therefore, without admixture or preparation, their ameliorating influence would probably result more from their large proportion of the elements of clay, giving the soil more consistence, and increasing its power of absorbing atmospheric agencies, &c., than from the alkalies or phosphoric acid, &c., they contain. In short, the application of these marls to the surface might be like the plowing up of a subsoil, rich in the mineral elements of plant food, but poor in the organic compounds which help to bring them into a soluble and available state.

Exposed to the atmospheric agencies, however, the insoluble silicates undergo a gradual, slow decomposition, and their valuable ingredients are thus set free for the use of plants. The decomposing remains of vegetables accelerate this process, and hence the great propriety of using these marls together with stable manure or other organic fertilizers, or of employing a clover or other green crop, plowed in, as a means of distintegrating the silicates. Doubtless poor exhausted land, which had been top-dressed with the marl, and then sowed in clover, which, after the growth of one or two seasons, was plowed in, would be found to be greatly improved in fertility. A similar result, in some degree, might possibly be obtained, in a single season, by the use of buckwheat, plowed in at maturity.

A quicker mode of setting free the alkalies, &c., of these marls, would necessarily be more expensive. The process used in the chemical analysis, viz: that of heating, to a moderate red heat, the mixture of the finely-ground marl with a large proportion of pulverized carbonate of lime, and about an equal proportion of sal ammoniac (ammonium chloride), is quite effectual in separating all the alkalies of the insoluble silicates. But it is somewhat expensive on a large scale. In this process the mutual reaction of the carbonate of lime and sal ammoniac produces carbonate of ammonia, which evaporates and is lost, and calcium chloride, which, together with the excess of carbonate of lime present (calcined in the process partly into caustic lime), cause the decomposition of the

silicates, and set free the alkalies. Calcium chloride and carbonate of lime, then, are the essential decomposing agents in this process; and as calcium chloride is present in the bittern water of all salt-works, and frequently thrown away as a waste product in other manufactories, or may be cheaply made by the application of hydrochloric acid to limestone, this process would be much more economical than that of the use of the ammonia salt. Under the head of Clay county, in the present volume, are some remarks on the proposition to use the bittern water of salt-works for this purpose—an application of this waste product, which is yet more promising, from the fact that this water contains potash and other salts, which may also be valuable on the exhausted soil.*

But, for the decomposition of the marl, not only must it be brought into a plastic state or be powdered, but the limestone or lime, with which it is to be mixed, must also be in the form of powder, so that they may be intimately mixed together and fully incorporated with the calcium chloride. With a cheap power and a good mill this might not be very expensive. In order to calcine the mixture, the plastic mass, produced by working up together the marl, lime, and solution of calcium chloride, should be made up into lumps or brick-like masses, dried to a certain extent, and then calcined at a moderate red heat, not sufficient to fuse them. The time during which they should be maintained at a red heat need not exceed a few hours.

Other modes might be available; as by the use of chlorine gas, which, if the lumps of the marl are porous, would not necessitate pulverization. This gas is to be cheaply obtained from the low-priced hydrochloric acid and oxide of manganese mixed, and if it be allowed to pass slowly from above through the marl lumps contained in a tall, tight cylindrical receptacle, would exert considerable decomposing influence upon the sil-

* It is generally believed that magnesium chloride is injurious to vegetation. As this is present in the bittern water, careful experiments to test its utility would be necessary. But the magnesium chloride would be decomposed by the lime in the process of calcination, and the free magnesia thus separated would not probably be injurious, notwithstanding the long-standing prejudice against this earth.

icates. This process would doubtless be at least as expensive as the above named.

The mere mixture of slacked lime with the powdered marl, when applied to the land, would doubtless be beneficial in accelerating its decomposition, and calcining them together at a moderate red heat might be yet more useful, especially if a little common salt be added. Indeed, merely calcining the clay alone, if the heat is not sufficient to fuse it, seems to set some of its alkaline constituents free; and hence, probably, one reason of the improvement of old soil by the English practice of paring and burning it. In numerous cases the writer has found the insoluble silicates to become more decomposable by the action of the acids after ignition.*

No. 1794—"LIMONITE IRON ORE, *containing clay iron-stone. Old Nolin Furnace property, three and a half miles north of Bee Spring. West of the road at the head of one of the forks of Decker Branch. On the road near the Brownsville and Grayson Springs road. Average sample by P. N. Moore.*"

Generally soft and porous, of a brownish-yellow color, with denser and darker colored irregular laminæ, and some nodules or portions of bluish-grey, fine granular clay iron-stone, which is somewhat oölitic, with small whitish particles.

COMPOSITION, DRIED AT 212° F.

Iron peroxide	48.913	= 36.526 iron.	
Iron carbonate	5.735		
Alumina	7.125		
Lime carbonate	9.410		
Magnesia carbonate	.144		
Phosphoric acid	.489	=	.209 phosphorus.
Sulphuric acid	.199	=	.080 sulphur.
Combined water and loss	8.905		
Silica and insoluble silicates	19.080	Containing 16.760 silica.	
	100.000		

A good and sufficiently rich ore, with but a moderate proportion of phosphorus, likely to yield a good quality of iron, if properly smelted. It contains nearly ten per cent. of carbonate of lime, which will aid in fluxing it.

*The simultaneous use of the marl and slacked lime as a top-dressing on a clover crop, or as a preparation for a crop of clover, which is subsequently plowed under, would no doubt be quite ameliorating to the soil.

GREENUP COUNTY.

COALS.

No. 1795—"*Coal, from Turkey Lick bed, on Turkey Lick. Collected by A. R. Crandall.*"

A splint coal. Some parts seemingly quite pure, with but little fibrous coal; other portions in thin shaly layers, with granular pyrites in the fibrous coal.

No. 1796—"*Coal* 3. *Turkey Lick Coal. Pennsylvania Furnace. Average sample from the lower and middle parts of the coal.*"

A splint coal, separating into thin laminæ, with fibrous coal and fine granular pyrites between.

No. 1797—"*Coal, from Turkey Lick coal mines. Main entry. One hundred and eighty feet from the outcrop. Average sample taken at that spot. By A. R. Crandall.*"

A splint coal, pretty pure looking, but has some fine granular pyrites in the fibrous coal between its thin laminæ.

No. 1798—"*Turkey Lick Coal. Old entry. Hunnewell. Average sample by A R. Crandall.*"

Like the preceding, but having less of the thinly laminated portion, with fibrous coal and granular pyrites between.

No. 1799—"*Coal. Raccoon Furnace. Average sample by A. R. Crandall.*"

A splint coal, splitting into quite thin laminæ, with much light fibrous coal and some fine granular pyrites between them.

No. 1800—"*Coke, from Coal No.* 3. *Turkey Lick coal. Hunnewell Furnace. Collected by A. R. Crandall.*"

A bright spongy coke.

COMPOSITION OF THESE GREENUP COUNTY COALS AND COKE, AIR-DRIED.

	No. 1795.	No. 1796.	No. 1797.	No. 1798.	No. 1799.	No. 1800.
Specific gravity	1.347	1.331	1.280	1.332	1.384	.....
Hygroscopic moisture	4.24	4.00	4.56	4.60	4.22	19.20
Volatile combustible matters	34.76	37.70	36 68	34.80	30.10	
Coke	61 00	58.30	58.76	60.60	65.68	80.80
Total	100.00	100.00	100.00	100.00	100.00	100.00
Total volatile matters	39.00	41.70	41.24	39.40	34.32	19.20
Carbon in the coke	48.70	51.60	52.40	51.00	53.68	75.10
Ash	12.30	6.70	6.36	9.60	12.00	5.70
Total	100.00	100.00	100.00	100.00	100.00	100.00
Character of the coke	Spongy.	Dense spongy.	Light spongy.	Dense spongy.	Friable.	.....
Color of the ash	Light lilac-grey.	Lilac-grey	Very light lilac-grey.	Very light lilac-grey.	Light lilac-grey.	Nearly white.
Per centage of sulphur	1.601	2.645	0.682	0.667	0.925	0.666

By comparing the sulphur per centage in No. 1796, and in the coke made from it, No. 188, it will be seen that more than three fourths of the sulphur of the coal appears to be removed in the process of coking. But the smaller ash per centage in this coke seems to indicate that a purer sample of this coal was used in its manufacture.

GREENUP COUNTY PIG IRONS.

No. 1801—"*Pig Iron. No.* 1 *Foundry iron. Hunnewell Furnace.*"

Quite a coarse-grained, light-grey iron. Somewhat hard, but yields to the file.

No. 1802—"*Pig Iron. No.* 1 *hot-blast silver-grey or glazed pig. Pennsylvania Furnace.*"

Moderately fine granular; whitish. Yields to the file and extends very little under the hammer. Quite brittle.

No. 1803—"*No.* 1 *Foundry Iron. Pennsylvania Furnace.*"

Coarser grained and darker than the preceding. Yields to the file; extends a little under the hammer.

No. 1804—"*Mill Iron. Pennsylvania Furnace.*"

Finer grained, darker, and more dull than the preceding. Extends considerably under the hammer.

No. 1805—"*No. 2 Foundry Iron. Pennsylvania Furnace.*"

Moderately fine-grained. Yields to the file; extends but little under the hammer.

No. 1806—"*No. 2 Cold-blast Iron; made from blue ore alone. Laurel Furnace. Collected by P. N. Moore.*"

A dark-grey, fine-grained iron. Extends somewhat under the hammer, but is brittle.

No. 1807—"*Mill Iron. Hot-blast. Third casting with stone-coal. Raccoon Furnace. Collected by P. N. Moore.*"

A fine granular iron. Yields to the file, and extends somewhat under the hammer.

COMPOSITION OF THESE GREENUP COUNTY PIG IRONS.

	No. 1801	No. 1802	No. 1803	No. 1804	No. 1805	No. 1806	No. 1807
Specific gravity	. . . .	. . . .	. . . .	. . . .	. . . .	6.680	6.927
Iron	92.284	90.630	92.060	94.764	92.856	92.697	91.596
Graphite	2.960	2.500	2.700	2.900	3.230	2.100	2.900
Combined carbon . . .	.690	.830	.630	.780	. . . .	1.000	.250
Silicon	3.011	4.969	3.104	1.193	2.545	1.813	3.477
Slag	.880	.360	.300	.200	.360	not est.	.800
Phosphorus	.474	.741	.710	.860	.817	.454	.247
Sulphur.	not est.	.040	.033	.033	.046	.218	.237
Undetermined and loss.	. . . .	. . . .	.463	. . . .	.146	1.718	.493
Total	100.299	100.070	100.000	100.730	100.000	100.000	100.000
Total carbon	3.650	3.330	3.330	3.680	3.230	3.100	3.150

While the total quantity of carbon in these pig irons does not vary much, there is a considerable difference in the proportions of silicon and phosphorus, both of which tend to make the iron brittle in the cold. The condition of the carbon, whether it be in the state of graphite or in combination

with the iron, makes a great difference in the quality of the metal, as is well known.

The cold-blast iron, No. 1806, made mostly from the "blue ore" (clay iron-stone), seems to contain nearly as much sulphur as the hot-blast iron, No. 1807, made with stone coal. The label does not state what was the character of the fuel used to smelt the former.

No. 1808—"IRON FURNACE SLAG, *from Raccoon Furnace, Green-up county. 'Mine-fall cinder,' with which little iron is made, but much slag. Collected by A. R. Crandall.*"

Of a dark bottle-green color; nearly black in the mass; transparent in the thin edges. Quite fusible, without intumescence, before the blow-pipe.

SPECIFIC GRAVITY = 2.868.

COMPOSITION.

Silica	47.960	Containing of oxygen.		24.902
Alumina	18.841		8.807	
Lime	20.462		5.819	
Magnesia	1.354		.451	
Iron protoxide	8.489	= 6.062 iron	1.887	
Manganese protoxide	not est.			
Phosphoric acid	.127	= .055 phosphorus.		
Sulphuric acid	.192	= .077 sulphur.		
Potash	2.045		.347	
Soda	.405		.104	
Loss	.125		17.415	24.902
Total	100.000			

The proportion of oxygen in the *bases* to that in the *silica* is as 1 : 1.423 in this slag, and as the proportions in a good slag are about as 1 : 2, it is evident that too little lime has been used in the flux, and that consequently a large proportion of iron oxide has formed glass with the excess of silicious matter, causing a serious loss. This cinder contains quite a considerable proportion of alumina, which seems to have carried with it more than the usual quantity of phosphoric acid into the cinder. The fact that the iron furnace slag may contain this injurious ingredient, and that probably alumina, lime in sufficient quantity being present, might be more instrumental

than any other material in the flux in removing it from the ore in the smelting furnace, contrary to the prevalent belief, was pointed out by the writer in volume 4th of the first series of Kentucky Geological Reports, page 44.

SOILS OF GREENUP COUNTY.

No. 1809—"*Virgin Soil. Woods. Sample taken to six inches below the surface. Top of a hill (ridge), eight feet above bed of coal. White Oak Creek, near Kenton Furnace. Collected by J. A. Monroe.*"

Dried soil of a brownish-grey color, mostly in friable lumps. Contains some fragments of ferruginous sandstone, and no quartz sand.

No. 1810—"*Subsoil to the preceding, taken eighteen inches below the surface. By J. A. Monroe.*"

Dried soil somewhat lighter colored than the preceding. Contains more ferruginous sandstone fragments, and some small hollow nodules of limonite ore. The bolting-cloth separated from the silicious residue a few minute quartzose particles.

No. 1811—"*Surface Soil to the depth of six inches, from a cornfield which has been in cultivation ten years. Valley of White Oak Creek. About ten feet above the bed of the creek. Collected by J. A. Monroe.*"

Soil of a light umber-grey color, mostly in friable lumps. The silicious residue contained a few small rounded grains of hyaline quartz.

No. 1812—"*Subsoil to the preceding, taken at eighteen inches below the surface. J. A. Monroe.*"

Subsoil of a light umber-grey color, slightly darker than the preceding. Contains fragments of brownish ferruginous sandstone.

COMPOSITION OF THESE GREENUP COUNTY SOILS, DRIED AT 212° F.

	No. 1809	No. 1810	No. 1811	No. 1812
Organic and volatile matters	5.590	5.600	4.375	3.790
Alumina and iron and manganese oxides	12.357	15.693	7.060	6.656
Lime carbonate	.045	.070	.270	.745
Magnesia	.366	.375	.083	.067
Phosphoric acid	.083	.147	.115	.109
Sulphuric acid	.003	a trace.	.027	.033
Potash	.433	.474	.098	.193
Soda	.023	.305	.068	.163
Soluble silica	.130	.095	.080	.135
Sand and insoluble silicates	79.500	76.060	86.890	87.665
Water, expelled at 388° F.	1.250	.950	1.100	.910
Loss	.220	.231	. . . .	. . . .
Total	100.000	100.000	100.166	100.466
Hygroscopic moisture	1.900	2.235	1.150	1.000
Potash in the insoluble silicates	2.301	2.829	1.220	0.817
Soda in the insoluble silicates	.509	.368	.520	.380
Character of the soil	Virgin woodla'd	Subsoil.	Cultivated field.	Subsoil.

As is frequently the case, there is great variety in the character of these coal-measure soils; those from the hill-top being quite rich, while the others from the valley are much less fertile: anomalous differences, evidently attributable to the original sources whence the soils were derived, or to the action of drainage waters, or other causes not known to us.

HANCOCK COUNTY.

COALS.

No. 1813—"*Cannel Coal. Cloverport Oil Company's mines, about eight miles south of Cloverport. Entry No.* 12, *at main breast. Base of the coal measures. Average sample by C. J. Norwood. Average thickness of the coal two and a half feet. It varies from twenty-two to thirty-six inches.*"

A dull-looking, very tough cannel coal. Has no marked appearance of pyrites.

No. 1814—"*Coal, from Hancock Coal Company's mines, below Hawesville. (Owned by the American Cannel Coal Company.) Collected by P. N. Moore.*"

Quite a pure-looking, firm, pitch-black coal. Has some little bright pyritous scales and fine granular pyrites between the laminæ.

No. 1815—"*Coal, from Milton Lawson's bank. Lead Creek, three miles from Hawesville. Average sample by P. N. Moore.*"

A splint coal, splitting into thin laminæ, with considerable fibrous coal and some granular pyrites between. Some external ferruginous stain. Has the appearance of having been weathered.

No. 1816—"*Coal, from Robt. Estes' bank. Back of Lewisport. Sample by P. N. Moore.*"

A pitch-black, rather firm coal, not all breaking into thin laminæ. Has much fibrous coal and granular and lamellar pyrites.

No. 1817—"*Coal, from James Mason's bank, between Hawesville and Lewisport. Sample by P. N. Moore.*"

Generally pitch-black and glossy—partly dull—on the cross fracture. Not generally breaking into thin laminæ. Has not much fibrous coal, but considerable appearance of granular pyrites, and some external ferruginous incrustation.

No. 1818—"*Coal, from Colbert's bank, near Lewisport. Sample by P. N. Moore.*"

A firm, pitch-black, glossy coal. Not much fibrous coal, but considerable shining pyritous scales and granular pyrites. Does not all split into thin laminæ.

No. 1819—"*Coal, from Bergenroth's bank, near old Reverdy mines. Sample by P. N. Moore.*"

A firm coal, not all breaking into thin laminæ. Has considerable fibrous coal between the laminæ, and some granular pyrites and external ferruginous stain.

No. 1820—"*Coal, from John C. Schafer's bank. Blackford Creek. Sample by P. N. Moore.*"

A pitch-black, firm, glossy coal. Considerable fibrous coal between some of the laminæ, and a few thin shining pyritous scales in the seams.

No. 1821—"*Coal, from the Breidenback bank. Lead Creek. Sample by P. N. Moore.*"

Generally glossy pitch-black, with some dull, thin laminæ, having fibrous coal between, and visible pyritous scales and granular pyrites.

No. 1822—"*Coal, from the Davidson bank, near Hawesville. Sample by P. N. Moore.*"

Appears to be a weathered specimen, having considerable ferruginous stain. Otherwise resembling the preceding.

No. 1823—"*Coal, from R. S. Lanum's bank, near Hawesville. Sample by P. N. Moore.*"

Resembles No. 1821.

COMPOSITION OF THESE HANCOCK COUNTY COALS, AIR-DRIED.

	No. 1813.	No. 1814.	No. 1815.	No. 1816.	No. 1817.	No. 1818.	No. 1819.	No. 1820.	No. 1821.	No. 1822.	No. 1823.
Specific gravity	1.213	1.357	1.353	1.323	1.289	1.401	1.336	1.308	1.292	1.268	1.292
Hygroscopic moisture	1.30	5.12	5.40	3.50	4.80	4.50	5.20	7.46	5.10	3.30	6.00
Volatile combustible matters	59.60	36.28	34.80	43.40	38.90	37.60	38.70	33.14	41.20	39.00	37.80
Coke	39.10	58.60	59.80	53.10	56.30	57.90	56.10	59.40	53.70	57.70	56.20
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Total volatile matters	60.90	41.40	40.20	46.90	43.70	42.10	43.90	40.60	46.30	42.30	43.80
Fixed carbon in the coke	27.00	47.60	49.30	45.56	50.06	47.46	48.50	55.20	46.60	50.50	48.70
Ash	12.10	11.00	10.50	7.54	6.24	10.44	7.60	4.20	7.10	7.20	7.50
Total	100.00	100 00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Character of the coke	Dense friable.	Dense.	Spongy.	Light spongy.	Light spongy.	Dense spongy.	Dense spongy.	Dense spongy.	Light spongy.	Light spongy.	Spongy.
Color of the ash	Light gr.-brown.	Lilac-grey	Light brownish-grey.	Purplish-chocolate.	Light brownish-grey.	Light chocolate.	Light lilac-grey.	Light grey	Light lilac-grey.	Brownish-grey.	Greyish-lilac.
Per centage of sulphur	1.890	4.038	2.398	4.155	2.316	7.809	2.266	1.368	3.331	3.373	3.180

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Coal No. 1813, from the Cloverport Oil Company's mines, is remarkable for the large proportion of volatile combustible matters it yields.

HARLAN COUNTY.

COALS.

No. 1824—"*Cannel Coal or Bituminous Shale, from Long Branch of Martin's Fork. Average sample of the weathered outcrop by P. N. Moore. Bed thirty-eight inches thick.*"

A dull-black, tough cannel coal. Fracture large conchoidal, somewhat in layers. Some ferruginous and earthy incrustation.

No. 1825—"*Coal, from J. C. Howard's bank. Clover Fork of Cumberland river, one mile above Mount Pleasant. Sample by P. N. Moore from near the limited outcrop. Bed four and a half feet thick.*"

A bright, pitch-black coal (semi-bituminous), having very little fibrous coal, and no visible pyrites.

No. 1826—"*Coal, from Martin's Fork, Skidmore Creek. Taken from near the outcrop, by A. R. Crandall. Bed forty-two inches thick.*"

A much weathered sample, containing much powdered coal.

COMPOSITION OF THESE HARLAN COUNTY COALS, AIR-DRIED.

	No. 1824.	No. 1825.	No. 1826.
Specific gravity	1.510	1.289	1.356
Hygroscopic moisture	1.40	1.70	5.20
Volatile combustible matters	34.60	35.70	31.26
Coke	64.00	62.60	63.54
Total	100.00	100.00	100.00
Total volatile matters	36.00	37.40	36.46
Fixed carbon in the coke	39.40	59.60	60.08
Ash	24.60	3.00	3.46
Total	100.00	100.00	100.00
Character of the coke	Dense.	Very light spongy.	Pulverulent.
Color of the ash	Chocolate.	Light buff.	Light buff.
Per centage of sulphur	1.271	0.750	0.618

No. 1824 contains a very large proportion of earthy matter, and might probably be considered bituminous shale. This, however, does not prevent it from yielding even more volatile combustible matters than 1826, and nearly as much as 1825. Its specific gravity is correspondingly high. The other coals yield less than the average quantity of ash, and give a large proportion of coke, and are superior coals, especially for the manufacture of iron, &c.

HENRY COUNTY.

No. 1827—"METALLIC LEAD, *from the 'Silver and Spar Mines,' three miles below Lockport, in the Lower Silurian. Collected by C. J. Norwood.*"

Brought to the laboratory to be examined for silver. On a careful analysis, by the wet way, no evidence of the presence of that metal was found, although more than fourteen grammes were examined.

No. 1828—"LIMESTONE, *Lower Silurian, from the same locality as the above. Collected by C. J. Norwood.*"

A fossiliferous, coarse granular limestone, of grey and buff colors, containing more or less calc. spar, and having small irregular cavities lined with ochreous iron oxide.

COMPOSITION, DRIED AT 212° F.

Lime carbonate	95.770
Magnesia carbonate	1.378
Alumina and iron and manganese oxides, and phosphoric acid	1.060
Sulphuric acid, alkalies, &c.	undeter'ed
Insoluble silicates	.980
Total	99.188

A good limestone, containing 53.631 per cent. of lime.

HOPKINS COUNTY.

COALS.

No. 1829—"*Coal D, from Diamond coal mine, about three quarters of a mile south of Earlington. (St. L. & S. E. R. R.) Average sample from along the entry, by C. J. Norwood.*"

A splint coal. Outer surfaces of most of the lumps somewhat soiled with dirt.

No. 1830—"*Coal D, from Saint Bernard coal mines, near Earlington. Upper drift. Bed three to four and a half feet thick. Average sample by C. J. Norwood.*"

A deep black, glossy splint coal, with but little fibrous coal between the laminæ, and no appearance of pyrites. Some thin plates of gypsum in the seams.

No. 1831—"*Coal B, from Fleming coal mine, one mile below Earlington. Bottom part two feet thick. Sample by C. J. Norwood.*"

A pitch-black, glossy coal. Some fibrous coal and fine granular pyrites between some of the laminæ, and bright pyritous and lime sulphate scales in some of the seams.

No. 1832—"*Coal B; same locality as the preceding. Top portion; four feet thick. Collected by C. J. Norwood.*"

Resembles the preceding.

No. 1833—"*Coal B, from Hecla coal mines. St. L. & S. E. R. R., near Earlington. Average sample by C. J. Norwood.*"

A pitch-black, glossy coal. But little fibrous coal between the laminæ. The sample has some thin scales of gypsum in some of the seams, and has some fragments in it of a thin pyritous shaly parting.

No. 1834—"*Coal B. Hecla mines, near Earlington. Average sample from the lower bench; about two feet four inches thick. By C. J. Norwood.*"

Resembles the preceding.

No. 1835—"*Coal B. St. Bernard coal mines, near Earlington. Lower drift. Average sample from the upper member; four feet thick. By C. J. Norwood.*" (*See also* 1830.)

Resembles No. 1830. Has some scaly incrustations of lime sulphate.

No. 1836—"*Coal D, from Hecla coal mines. Earlington. Carefully sampled by C. J. Norwood.*

A pitch-black coal. Very little fibrous coal. Some scales of lime sulphate, stained with iron oxide, in the seams, with some little shining pyrites.

	No. 1829.	No. 1830.	No. 1831.	No. 1832.	No. 1833.	No. 1834.	No. 1835.	No. 1836.
Specific gravity	1.351	1.337	1.366	1.290	1.323	1.326	1.326	1.331
Hygroscopic moisture	5.00	4.30	3.04	2.70	3.28	3.82	3.20	2.32
Volatile combustible matters	35.26	37.64	36.90	40.74	39.32	36.38	38.30	37.68
Coke	59.74	58.06	60.06	56.56	57.40	59.80	58.50	60.00
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Total volatile matters	40.26	41.94	39.94	43.44	42.60	40.20	41.50	40.00
Fixed carbon in the coke	49.24	50.56	49.06	51.64	49.54	51.10	48.50	51.00
Ash	10.50	7.50	11.00	4.92	7.86	8.70	10.00	9.00
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Character of the coke	*Lt. sp.	Lt. sp.	Lt. sp.	Lt. sp.	Lt. sp.	Lt. sp.	Lt. sp.	Lt. sp.
Color of the ash	Brownish-grey.	Dark brownish-grey.	Lilac-grey.	Light lilac-grey.	Lilac-grey.	Lilac-grey.	Lilac-grey.	Lilac-grey.
Per centage of sulphur	3.015	2.892	5.955	1.502	4.710	3.639	3.345	3.606

* Lt. sp. — Light spongy.

All of them good coals, although some few of them exceed the average per centage in ash and sulphur.

HOPKINS COUNTY SOILS.

No. 1837—"*Virgin Soil, from woods, at Harrison Station, L. & S. E. R. R., about thirty miles from Henderson. Forest growth: white and red oaks, hickories, &c. Geological formation above the sandstone. Collected by C. W. Beckham.*"

Dried soil of an umber-grey color; contains a very little ferruginous gravel. The silicious residue all passed through the bolting-cloth.

No. 1838—"*Surface soil, from a field twenty years in cultivation in corn and tobacco; adjoining the locality of the preceding soil,*" *&c., &c.*

Color of the soil like that of the preceding. It contains no gravel nor fine silicious sand.

No. 1839—"*Subsoil of the next preceding,*" *&c., &c.*

Dried subsoil of a brownish-buff color; contains no gravel nor fine silicious sand.

No. 1840—"*Virgin Soil, from woods: Farm of J. D. Morton. Morton's Gap. St. L. & S. E. R. R. Forest growth: dogwood, sweet gum, white oak, &c., &c. Substratum sandstone. Collected by C. W. Beckham.*"

No. 1841—"*Surface Soil, from an old field fifty years in cultivation; next adjoining the preceding locality. Field said to have been once exhausted and overgrown with sassafras, black jack, elm, &c. Has been cleared again, and is now in tobacco. It has been most of the time in red-top meadow. Collected by C. W. Beckham.*"

Contains no gravel or fine silicious sand.

No. 1842—"*Subsoil of the next preceding,*" *&c., &c.*

Contains no gravel or sand.

No. 1843—"*Virgin Soil, from the farm of John Wilson, near Nortonsville. St. L. & S. E. R. R. Underlying rock sandstone. Collected by C. W. Beckham.*"

Contains no gravel, but the bolting-cloth separated from the silicious residue a considerable quantity of clear quartz grains, rounded and angular.

No. 1844—"*Surface soil, from an old field fifty years in cultivation; now overgrown with blackberry, sumach, &c., &c. Same locality as preceding,*" *&c., &c.*

Contains no gravel, but a considerable proportion of fine clear quartz grains, rounded and angular.

No. 1845—"*Subsoil of the next preceding,*" *&c., &c.*

Like the preceding, contains fine quartz grains.

COMPOSITION OF THESE HOPKINS COUNTY SOILS, DRIED AT 212° F.

	No. 1837	No. 1838	No. 1839	No. 1840	No. 1841	No. 1842	No. 1843	No. 1844	No. 1845
Organic and volatile matters	3.950	3.900	3.100	5.895	4.000	3.080	7.125	3.185	3.815
Alumina and iron and manganese oxides	5.845	5.936	10.321	5.649	6.153	7.224	6.322	5.155	10.090
Lime carbonate	.125	.235	.115	.385	.245	.245	.395	.120	.145
Magnesia	.088	.137	.035	.142	.092	.095	.162	.124	.269
Phosphoric acid	.080	.099	.064	.061	.032	.061	.163	.080	.045
Potash	.193	.086	.354	.348	.300	.498	.325	.292	.518
Soda	....	.145	....	.103	.213	.235	.020	.186	.251
Water, expelled at 380° F.	1.375	1.150	1.050	.625	.420	.550	.875	.430	.685
Sand and insoluble silicates	88.015	88.115	84.665	86.590	89.195	88.415	85.200	91.455	85.160
Total	99.671	99.803	99.704	99.798	100.650	100.403	100.587	101.027	100.978
Hygroscopic moisture	1.750	1.600	2.600	1.580	1.225	1.335	1.775	0.730	2.160
Potash in the insoluble silicates	1.686	1.528	1.149	1.336	1.272	1.236	1.152	1.163	1.247
Soda in the insoluble silicates	.425	.371	.621	.604	.588	.621	.493	.388	.488
Character of the soil	Virgin soil.	Cultivated soil.	Subsoil.	Virgin soil.	Old field soil.	Subsoil.	Virgin soil.	Old field soil.	Subsoil.

These soils do not appear to have been derived from the sandstone which underlies them, being richer than might be expected from such an origin, and containing no great quantity of sand. They have doubtless been formed by the disintegration of other superincumbent strata, richer in the fertilizing mineral elements, or been modified by the admixture of light drift material. The exhausting influence of culture is to be seen in each case, as shown by the generally smaller proportions of potash, phosphoric acid, organic and volatile matters, &c., and the large quantity of sand and insoluble silicates in the old field soil, as compared with the virgin soil of the next adjoining field.

These soils are not generally deficient in potash, except soil No. 1838, but their proportion of phosphoric acid is generally small, so that there is every reason to believe they would be much improved in productiveness by the use of phosphatic fertilizers, such as bone dust, superphosphate, or guano. As the tobacco culture is especially exhaustive of potash and lime, wood ashes, or some other fertilizer containing potash, might be advantageously used, together with the judicious application of lime. Both of these are best used with a clover crop, which should be plowed in after a growth of one or two years. By such a process the old exhausted fields might be greatly improved.

JACKSON COUNTY.

COALS.

No. 1846—"*Cannel Coal, from Tom Coyle's bank, seventeen miles southeast of Richmond. Represented to be twenty-one inches cannel and twenty-one inches bituminous coal. Bed about one hundred feet above the conglomerate. Sample from the weathered outcrop. By Wm. A. Gunn, Esq., Civil Engineer.*"

A rather dull-looking cannel coal. Splitting, with difficulty, into layers, with not enough fibrous coal to soil the fingers, and no apparent pyrites.

No. 1847—"*Cannel Coal, from T. J. Ballard's bank. Branch of Horse Lick, twenty-six miles from Richmond. A sub-conglomerate coal. Specimen from the outcrop. By Wm. A. Gunn, Esq.,*" *&c.*

Resembles the preceding. Has a bird-eye structure in parts.

COMPOSITION OF THESE JACKSON COUNTY COALS, AIR-DRIED.

	No. 1846.	No. 1847.
Specific gravity	1.338	1.321
Hygroscopic moisture	2.00	2.00
Volatile combustible matters	41.00	43.66
Coke	57.00	54.34
Total	100.00	100.00
Total volatile matters	43.00	45.66
Fixed carbon in the coke	43.10	45.58
Ash	13.90	8.76
Total	100.00	100.00
Character of the coke	Spongy.	Dense.
Color of the ash	Very light buff-grey.	Grey-lavender.
Per centage of sulphur	1.049	3.384

Although No. 1846 contains more than the average proportion of earthy matters, it is yet quite valuable for fuel, especially for domestic purposes. No. 1847 is not so liable to this objection, and is a very good cannel coal.

JESSAMINE COUNTY.

MINERAL WATER.

No. 1848—"*Salt Sulphur Water, from a bored well, ninety feet deep, at Nicholasville. Brought by Mr. R. A. Downing.*"

The water was obtained at eighty feet, and stands in the well at sixty feet from the surface. Lower Silurian formation.

Specific gravity of the water = 1.023.

The water when brought to the laboratory smelt slightly of sulphuretted hydrogen, and was quite cloudy from the presence of free sulphur, derived from the decomposition of that gas. It also contained free carbonic acid gas.

The per centage of *saline matters* contained in it is 2.828, dried at 212° F. They consist of lime and magnesia sulphates, and a considerable proportion of sodium chloride, with some lime, magnesia, and iron carbonates, marked traces of lithia, iodine, and bromine, and doubtless of salts of potash and soda.

A quantitative analysis was not made at this time, but the water resembles the salt sulphur waters generally obtained by boring into the Lower Silurian limestone formation, of which several analyses are given in previous volumes, and all of which are more or less like the celebrated waters of the Blue Lick Springs.

JOHNSON COUNTY.

COALS.

No. 1849—"*Cannel Coal, twenty-seven inches thick. Lick Branch, half a mile above the mouth of White House Creek. Ten miles above Peach Orchard. Collected by A. R. Crandall.*"

Contains some bright pyrites, and is somewhat incrusted with ferruginous material. Is generally a tough cannel coal.

No. 1850—"*Rice's Coal. Head of Jenny's Creek. Thirty inches thick. Average sample by A. R. Crandall.*"

A pure-looking, glossy-black coal, with but very little fibrous coal or pyrites. Somewhat hard and not breaking into so thin laminæ as the usual splint coals. Ferruginous stains on some of the seams.

No. 1851—"*Coal, from Wheeler's bank, near Paintsville. Bed four feet six inches thick, without parting. Average sample by A. R. Crandall.*"

A pure-looking, pitch-black coal. Rather firm. Has but little fibrous coal. Some few bright pyritous scales apparent.

COMPOSITION OF THESE JOHNSON COUNTY COALS, AIR-DRIED.

	No. 1849.	No. 1850.	No. 1851.
Specific gravity	1.291	1.294	1.281
Hygroscopic moisture	2.00	3.10	2.66
Volatile combustible matters	38.20	38.60	38.04
Coke	59.80	58.30	59.30
Total	100.00	100.00	100.00
Total volatile matters	40.20	41.70	40.70
Fixed carbon in the coke	51.00	53.50	56.30
Ash	8.80	4.80	3.00
Total	100.00	100.00	100.00
Character of the coke	Dense.	Light Spongy.	Spongy.
Color of the ash	Light lilac-grey.	Light brownish-grey.	Brownish-grey.
Percentage of sulphur	0.956	1.735	1.291

Remarkably good coals, containing less than the usual proportions of sulphur and earthy matters. Being also quite firm, they might very probably be employed, without coking, in the smelting of iron in the high furnace.

KNOX COUNTY.

No. 1852—FERRUGINOUS LIMESTONE. *Labeled "Rock from Poplar Creek; farm of W. H. Hutching. Specimen obtained from Col. John G. Eve by Prof. N. S. Shaler; together with a specimen of metal smelted from it."*

A compact, fine granular, grey rock; weathered yellowish-brown on the exterior. Fracture flat conchoidal. Some very small bright crystals of pyrites on the seams.

COMPOSITION, DRIED AT 212° F.

Iron carbonate	13.532	= 6.532 per cent. of iron.
Alumina	2.699	
Manganese carbonate	not det'd.	
Lime carbonate	42.260	
Magnesia carbonate	3.072	
Phosphoric acid	.089.	
Sulphuric acid	not det'd.	
Silicious residue	31.860	
Undetermined and loss	6.488	
	100.000	

This ferruginous limestone is too poor for use in smelting, except in mixture with richer ores, to answer as flux. Possibly it might make a hydraulic cement if properly calcined.

The bright white metal which accompanied this limestone, said to have been smelted from it, and supposed to contain silver, is simply white pig metal, containing more than ninety-two per cent. of iron, nearly one per cent. of phosphorus, 0.785 per cent. of silicon, 0.104 per cent. of sulphur and carbon, &c. It is quite brittle and crystalline, somewhat in appearance like antimony. Its color is more grey than that of silver.

KNOX COUNTY SOILS.

No. 1852 (*a*)—"*Virgin Soil, from the farm of A. B. Britton, three miles north of Barbourville, at the foot of Paint Hill Knobs. Collected by C. W. Beckham. Rock substratum; sandstone.*"

Dried soil of a light-brownish-grey color; contains some rounded ferruginous concretions. The bolting-cloth removed from the silicious residue a considerable proportion of small irregular particles of partly decomposed silicates, and a few minute scales of mica.

No. 1852 (*b*)—"*Surface Soil, from a field twenty years in cultivation, from same farm and near the locality of the next preceding. Collected by C. W. Beckham.*"

Dried soil, containing some friable lumps, of a light-grey, clayey soil, mixed with a light mouse-colored powdered soil and some ferruginous sandstone and cherty fragments. The bolting-cloth separated from the silicious residue a consider-

able portion of particles of partly decomposed silicates (as above).

No. 1852 (*c*)—"*Virgin Soil, from the top of Paint Hill Knob, three and a half miles north of Barbourville. Forest growth almost exclusively oak, hickory, and chestnut. (Location of a Signal Station of the U. S. Coast Survey.) Substratum sandstone. Collected by C. W. Beckham.*"

Dried soil of a dark, brownish-grey color; contains small cherty and ferruginous sandy fragments. The bolting-cloth removed from the silicious residue a considerable portion of minute particles of undecomposed silicates, a few reddish rounded quartzose particles and minute scales of mica.

No. 1852 (*d*)—"*Virgin Soil, from woods, on the farm of Judge Tuggle, one and a third miles south of Barbourville, in the Cumberland River Valley. Principal forest growth: oaks, hickories, &c. Substratum sandstone. Collected by C. W. Beckham.*"

Dried soil of a light-umber-grey color. Quite a light soil—as light as wood ashes—contains no gravel. The bolting-cloth removed from the silicious residue a considerable proportion of small rounded quartzose grains.

No. 1852 (*e*)—"*Surface Soil, from an old field sixty years in cultivation; now in meadow. Same locality as the next preceding,*" *&c., &c.*

Dried soil of a lighter umber-grey than preceding; resembles it in other respects.

No. 1852 (*f*)—"*Subsoil of the next preceding,*" *&c., &c.*

Dried soil of a lighter grey-buff color; contains no gravel, &c. (as above).

COMPOSITION OF THESE KNOX COUNTY SOILS, DRIED AT 212° F.

	No. 1852 *a*	No. 1852 *b*	No. 1852 *c*	No. 1852 *d*	No. 1852 *e*	No. 1852 *f*
Organic and volatile matters	3.453	4.374	5.658	2.800	2.765	1.750
Alumina and iron and manganese oxides	5.456	8.781	7.885	2.835	1.904	3.644
Lime carbonate	.100	.120	.095	.045	.130	.045
Magnesia	.158	.158	.158	.016	.029	.025
Phosphoric acid	.179	.104	.185	.055	.061	.031
Sulphuric acid	not est.	not est.	not est.	not est.	not est.	not est.
Potash	.125	.261	.467	.112	.094	.130
Soda	.576	not est.	not est.	.021	not est.	not est.
Sand and insoluble silicates	89.115	85.165	84.765	93.790	94.530	93.215
Water expelled at 380° F.	.741	.621	.909	.525	.535	1.675
Loss	.097	.416	. . . . .	. . . . .	. . . . .	. . . . .
Total	100.000	100.000	100.062	100.199	100.048	100.515
Hygroscopic moisture	0.815	0.900	1.025	0.950	0.435	0.435
Potash in the insoluble silicates	1.648	1.648	2.320	0.399	.409	.718
Soda in the insoluble silicates	.130	.446	.546	.235	.150	.119
Character of the soil	Virgin soil.	Cultivated soil.	Virgin soil.	Virgin soil.	Old field soil.	Subsoil.

Soils *a*, *b*, and *c* contrast favorably with soils *d*, *e*, and *f*; containing less sand and insoluble silicates and more potash, phosphoric acid, organic and volatile matters, &c. A marked difference may also be observed in the proportion of alkalies contained in the insoluble silicates. The first three named soils, indeed, are peculiar in containing more silicates of the felspathic and micaceous character than common, indicating a different origin from the latter named soils, and containing a large proportion of the alkalies. The soils *d*, *e*, and *f* may be called quite poor, naturally; but they can be made productive by proper management and the use of fertilizers, if they are sufficiently drained.

LAUREL COUNTY.

SOILS.

No. 1853—"*Virgin Soil, from a farm near Jackson's Steam Mill, nine miles south of London. Forest growth principally oaks and hickories. Geological formation, carboniferous sandstone. Collected by C. W. Beckham.*"

Dried soil of a brownish umber-grey color; contains some irregular fragments of ferruginous sandstone. The bolting-cloth separated from its insoluble silicious residue quite a large proportion of small rounded white quartz grains.

No. 1854—"*Surface Soil, from an old field. Same locality as the preceding,*" *&c.*

Dried soil of a lighter and more yellowish color than the preceding; contains less of fragments of ferruginous sandstone, but fully as much of fine rounded white quartz grains.

No. 1855—"*Subsoil of the preceding,*" *&c.*

Of a still lighter and more yellowish color (brownish-grey); contains no gravel, but a large proportion of minute white quartz grains.

No. 1856—"*Virgin Soil, from woods. Farm of Jefferson Cannifax, half a mile south of London. Forest growth almost exclusively oaks, a few maples, hickories, &c. Collected by C. W. Beckham.*"

Dried soil of a brownish umber-grey color; containing clods of somewhat lighter color. Contains fragments of ferruginous sandstone or concretions in considerable quantity. Silicious residue contains some rounded white quartz grains.

No. 1857—"*Surface Soil, from an old field sixty-five years in cultivation; uninclosed. Said to be worn out. Adjoining the woods from whence the preceding sample was taken. Substratum, carboniferous sandstone. Collected by C. W. Beckham.*"

Soil lighter colored than the preceding; contains fragments of ferruginous concretions or sandstone. Silicious residue contained some rounded white quartz grains.

No. 1858—"*Subsoil of the next preceding,*" *&c.*

Dried subsoil of a brownish-buff color; contains some ferruginous sandy concretions; less than in the two preceding. The insoluble silicious residue contained but a few quartzose grains.

COMPOSITION OF THESE LAUREL COUNTY SOILS, DRIED AT 212° F.

	No. 1853	No. 1854	No. 1855	No. 1856	No. 1857	No. 1858
Organic and volatile matters. . .	6.110	3.625	2.450	5.990	3.475	3.740
Alumina and iron and mang. ox's	5.298	4.882	5.719	7.339	7.361	9.385
Lime carbonate	.110	.130	.145	.070	.120	.110
Magnesia	.011	.025	.016	.124	.053	.075
Phosphoric acid	.077	.083	.071	.096	.099	.100
Potash	.229	.312	.110	.217	.074	.447
Soda	.149	.268	.228	. . . .	. . . .	. . . .
Sand and insoluble silicates . . .	87.330	90.230	90.780	84.415	87.740	85.365
Water, expelled at 380° F. . . .	1.100	.725	.400	1.075	.675	.725
Loss	. . . .	. . . .	.081	.674	.403	.053
Total	100.414	100.280	100.000	100.000	100.000	100.000
Hygroscopic moisture.	0.865	0.550	0.575	1.535	0.800	1.425
Potash in the insoluble silicates .	.843	.661	.892	.939	.862	.975
Soda in the insoluble silicates . .	.171	.211	.214	.400	.623	.575
Character of the soil	Virgin soil.	Old field soil.	Subsoil.	Virgin soil.	Old field soil.	Subsoil.

These soils are pretty uniform in character, and, but for a paucity of phosphoric acid, which may be seen in them all, would be classed as of good average quality.

LAWRENCE COUNTY.
BLACK BAND IRON ORES.

No. 1858—"*Black Band Ore, from near Louisa; sent by Col. John Rice. Bed said to be thirty-one inches thick, of which twelve to sixteen inches are black-band, the rest bituminous shale.*"

A dull greyish-black, fine granular ore; some little bright-yellow pyrites apparent.

No. 1858 (*a*)—"*Black Band Ore, from same locality as preceding. (Gavat farm, on the west fork of Big Sandy river. A four to six feet bed of coal just below it.) Brought by Mr. John R. Procter.*"

No. 1858 (*b*)—"*Average sample of the Black Band Iron Ore, on Louisa Fork of Big Sandy river, six miles south of Louisa. Collected by A. R. Crandall.*"

Thickness of the layer about two feet, of which only about eight to twelve inches are of Black Band Ore. Latterly it has been reported as sixteen inches, at the bottom of the black shale which constitutes most of the bed.

These several samples were examined as to their proportions of iron, phosphorus, sulphur, &c., with the following results:

	No. 1858.	No. 1858 *a*.	No. 1858 *b*.
Specific gravity	3.151	not det'd.	not det'd.
Iron	33.264	33.923	25.746
Phosphorus	not det'd.	not det'd.	.553
Sulphur	.483	not det'd.	.354
Lime	not det'd.	not det'd.	.924
Magnesia	not det'd.	not det'd.	.150
Bituminous matters	not det'd.	not det'd.	13.700
Silica	7.460	not det'd.	6.360
Alumina	not det'd.	not det'd.	17.920

The iron is mostly in the form of carbonate in the ore, as are also the lime and magnesia, and the phosphorus and sulphur in that of phosphoric and sulphuric acids. The proportions of these two latter ingredients are somewhat large, but yet not so great as to prevent this ore from being made profitably available for foundry iron, &c., if it is to be obtained in sufficient abundance and as rich in iron as the samples 1858 and 1858 (*a*).

LAWRENCE COUNTY COALS.

No. 1859—"*Peach Orchard Coal.* (*Coal No.* 3.) *Miller's Branch opening. Collected by A. R. Crandall.*"

A pitch-black coal, breaking in thin laminæ, with some fibrous coal and fine granular pyrites between. Some external ferruginous stain.

No. 1860—"*Peach Orchard Coal.* (*Coal No.* 3.) *Same locality. Sample somewhat weathered. Collected by A. R. Crandall.*"

No. 1861—"*Cannel Coal. Little Laurel Creek. Collected by A. R. Crandall.*"

Shows very little pyrites.

COMPOSITION OF THESE LAWRENCE COUNTY COALS, AIR-DRIED.

	No. 1859.	No. 1860.	No. 1861.
Specific gravity	1.317	not est.	1.245
Hygroscopic moisture	3.26	3.24	1.84
Volatile combustible matters	34.22	36.56	48.16
Coke	62.52	60.20	50.00
Total	100.00	100.00	100.00
Total volatile matters	37.48	39.80	50.00
Fixed carbon in the coke	55.36	54.96	44.74
Ash	7.16	5.24	5.26
Total	100.00	100.00	100.00
Character of the coke	Dense.	Dense.	Dense.
Color of the ash	Light brownish-grey.	Light lilac-grey.	Buff.
Per centage of sulphur	0.901	1.189	1.076

The Peach Orchard coal has a high reputation where it is brought into market, and many samples show a much smaller proportion of ash than is given above. An analysis reported by the late Dr. Owen (volume I, old series, Kentucky Geological Reports, page 69) gives only the small ash per centage of 2.85. The proportion of sulphur is also quite small. This coal is a semi-cannel or splint coal, and might very probably be employed with advantage in the smelting of iron, without coking. It is an admirable fuel for domestic purposes.

LAWRENCE COUNTY LIMONITE IRON ORES.

No. 1862—"*Limestone Ore; portions of three samples, from different localities, mixed. On upper Blaine Creek. Collected by A R. Crandall.*"

No. 1863—"*Red Kidney Ore, from near the mouth of Cherokee Creek, about fifty feet above the limestone ore. Collected by A. R. Crandall.*"

COMPOSITION OF THESE LIMONITE ORES, DRIED AT 212° F.

	No. 1862.	No. 1863.
Iron peroxide	67.515	55.693
Alumina	1.280	1.151
Manganese oxide	not est.	not est.
Lime carbonate	a trace.	a trace.
Magnesia	a trace.	a trace.
Phosphoric acid	.135	.284
Sulphuric acid	.423	.302
Combined water	10.150	10.510
Silicious residue	20.480	31.280
Loss	.017	.780
Total	100.000	100.000
Per centage of iron	47.250	39.105
Per centage of phosphorus	.059	.124
Per centage of sulphur	.175	.111
Per centage of silica	16.960	25.660

These are quite good iron ores, rich enough in iron, and containing less than the usual proportion of phosphorus.

No. 1864—"BITUMINOUS SILICIOUS PETRIFACTION. *Irish Creek. Probably associated with Coal No. 2. Collected by A. R. Crandall.*"

Presenting the appearance of fibrous coal which has been infiltrated with silica.

COMPOSITION, AIR-DRIED.

Silica and silicates	80.66
Carbonaceous matter	13.40
Alumina and iron oxide, &c.	1.80
Lime carbonate	.26
Water and loss	3.88
Total	100.00

LEE COUNTY.

COALS.

No. 1865—"*Coal, from Daniel Scott's bank, three quarters of a mile above Proctor. Bed thirty-six inches thick. Sample by A. R. Crandall.*"

A pitch-black splint coal, having but little fibrous coal. Some fine granular pyrites between the thin laminæ.

No. 1866—"*Coal, from the same locality as the last, from another entry. Bed forty-one inches thick. Sample by A. R. Crandall.*"

Resembles the preceding.

No. 1867—"*Pryse's Coal. Lower Stufflebean Creek. Three quarters of a mile west of Beattyville. Average sample from two places, two hundred and two hundred and eighty-six yards from the mouth of the entry. By A. R. Crandall. Thickness of bed thirty-six to forty inches.*"

A pure-looking, pitch-black, glossy splint coal, with very little fibrous coal and fine granular pyrites between the laminæ.

No. 1868—"*Coal, from Phillips' bank, on Mirey Branch. Probable average thickness of the bed forty inches. Average sample from the stock pile, by A. R. Crandall.*"

Resembles the preceding; contains some small scales of bright pyrites.

No. 1869—"*Coal, from R. B. Jameson's bank, two miles below Beattyville, on Mike's Branch. Average sample by A. R. Crandall.*"

A splint coal. Has some fibrous coal and granular pyrites.

COMPOSITION OF THESE LEE COUNTY COALS, AIR-DRIED.

	No. 1865.	No. 1866.	No. 1867.	No. 1868.	No. 1869.
Specific gravity	1.331	1.334	1.307	1.307	1.330
Hygroscopic moisture	2.30	2.10	4.00	3.10	3.40
Volatile combustible matters . .	38.10	38.10	35.50	36.64	32.70
Coke	59.60	59.80	60.50	60.26	63.90
Total	100.00	100.00	100.00	100.00	100.00
Total volatile matters	40.40	40.20	39.50	39.74	36.10
Fixed carbon in the coke . . .	51.64	51.54	55.50	56.96	57.60
Ash	7.96	8.26	5.00	3.30	6.30
Total	100.00	100.00	100.00	100.00	100.00
Character of the coke	Light spongy.	Spongy.	Light spongy.	Dense spongy.	Spongy.
Color of the ash	Lilac-grey.	Lilac-grey.	Light lilac-grey.	Light buff-grey.	Light lilac-grey.
Per centage of sulphur	2.356	3.991	1.041	1.030	1.368

These coals resemble, in their general properties, those of Lawrence county, reported on above; and although some of these contain a little more sulphur than those, the remarks appended to the latter are equally applicable to these.

LEWIS COUNTY.

SOILS.

No. 1870—"*Soil, from the Ohio bottom, border of creek; ten feet from its surface, about three and a half miles above Quincy. Collected by N. S. Shaler.*"

Dried soil mostly in friable lumps, of a light brownish-grey color; contains no gravel. Silicious residue contains quartzose sand, which will not pass through fine bolting-cloth.

No. 1871—"*Subsoil of the preceding; taken one to three feet below the surface,*" *&c., &c.*

Dried subsoil in friable lumps, somewhat lighter colored than the surface soil; of a light yellowish-grey color.

No. 1872—"*Old Field Soil, cultivated for over fifty years; never overflowed. Back of the Ohio bottom, on Scaffold (or "Scuffle") Creek, three and a half miles above Quincy, and above locality of the two preceding. Produces forty bushels of corn to the acre on an average. Collected by N. S. Shaler.*"

Dried soil of a light-grey color, slightly less yellowish than the next preceding, and slightly darker.

COMPOSITION OF THESE LEWIS COUNTY SOILS, DRIED AT 212° F.

	No. 1870.	No. 1871.	No. 1872.
Organic and volatile matters	3.325	2.665	4.425
Alumina and iron and manganese oxides	10.965	8.995	9.545
Lime carbonate	.125	a trace.	.180
Magnesia	.266	.092	.208
Phosphoric acid	.125	.125	.205
Sulphuric acid	a trace.	.015	.050
Potash	.501	.387	.462
Soda	.116	.128	.134
Soluble silica	.095	.095	.085
Sand and insoluble silicates	83.465	86.365	83.100
Water expelled at 380° F.	1.025	.685	1.725
Loss	. . . . .	.448	. . . . .
Total	100.008	100.000	100.119
Hygroscopic moisture	3.000	2.225	2.335
Potash in the insoluble silicates	1.843	1.233	1.138
Soda in the insoluble silicates	1.036	.868	.954
Character of the soil	Surface soil.	Subsoil.	Old field soil.

These soils, evidently composed of fine detritus deposited by the water of the river, contain more than the average quantity of potash in a state of combination soluble in acids, and hence immediately available for plant growth. The proportions of organic and volatile matters, of phosphoric acid and lime, as well as of the alkalies in the insoluble silicates, are not more than the average. No. 1871 subsoil is especially deficient in lime. Yet they may well be characterized as fertile soils, more especially No. 1872.

LINCOLN COUNTY.

No. 1873—"CLAY, *from the head waters of Green river, on the land of Mr. Thos. W. Varnon. Bed two to four feet from the surface, and said to be forty-two to forty-five feet thick; resting on black shale, which is fifty feet thick. Salt water is found by boring at the depth of eighty-four feet, and some little petroleum in the sandstone. Sent by Senator Varnon.*"

Clay imperfectly laminated, of a dark olive-grey color. Fuses before the blow-pipe. Burns of a grey-buff color.

COMPOSITION, DRIED AT 212° F.

Silica	61.580
Alumina	23.946
Iron protoxide	5.814
Lime	.201
Magnesia	.850
Potash	1.542
Soda	.362
Water and loss	5.705
Phosphoric acid	not det'd.
Total	100.000

The considerable proportions of the iron oxide, lime, potash, and soda prevent this clay from being refractory in the fire. But while it is therefore unfit for the manufacture of fire-bricks, it will yet answer well for ordinary pottery, terra cotta work, or tiles.

CRAB ORCHARD SALTS (SO-CALLED).

The saline matters obtained by the evaporation of the saline waters of Crab Orchard and vicinity, Lincoln county.

No. 1874—"*Crab Orchard Springs Salts; put up by the Crab Orchard Salts Company. Said to be obtained from the waters of various springs mixed. Evaporated at the Springs, and warranted genuine, as sold in sealed bottles by J. B. Wilder & Co., Louisville.*"

A granular salt, colored light-buff with iron peroxide. Dried for about a month, in the water-bath it lost 33.715 per cent. of

its weight by the evaporation of water; mainly water of crystallization.

No. 1875—"*Crab Orchard Salts; furnished by Messrs. Arthur Peter & Co., Louisville, from their stock; obtained by Dr. Laney Egbert, druggist, of Crab Orchard. Said also to be derived from various springs.*"

This also is in granular lumps, and presents various shades of buff color, from the presence of iron peroxide.

COMPOSITION OF THESE SAMPLES OF CRAB ORCHARD SALTS, DRIED AT 212° F.

	No. 1874.	No. 1875.
Magnesia sulphate	54.842	60.627
Soda sulphate	13.566	8.260
Potash sulphate	2.707	2.814
Lime sulphate	2.149	1.795
Lithia sulphate	.038	.028
Sodium chloride	2.954	1.874
Lime carbonate	.032	.018
Magnesia carbonate	.089	.036
Iron peroxide	.078	.028
Silica	.124	.118
Water of crystallization and loss	23.421	24.402
Total	100.000	100.000

These salts have quite an extensive medicinal use in some localities. The proportions of lithium salt shown in the above analyses is not so great as is generally claimed for these salts.

MADISON COUNTY.

CLAYS.

No. 1876 (*a*)—"*Potter's Clay (quality No. 1). Upper Silurian. Waco, nine miles east of Richmond. Collected by A. R. Crandall.*"

A light-grey soft clay, with some ochreous stains and infiltration.

No. 1876 (*b*)—"*Potter's Clay (quality No. 2). Same locality,*" *&c., &c.*

Of a bluish-grey color.

COMPOSITION OF THESE CLAYS, DRIED AT 212° F.

	No. 1876 *a*.	No. 1876 *b*.
Silica	59.976	56.960
Alumina, iron and manganese oxides, and phosphoric acid	27.640	28.740
Lime carbonate	.280	.200
Magnesia	.606	.752
Potash	3.931	2.502
Soda	.547	.315
Combined water and loss	7.020	10.531
Total	100.000	100.000

Neither of these would answer for fire-clay, because of their large proportions of alkalies, lime, magnesia, iron oxide, &c. The iron was not separately determined, and hence the reason why the one is better than the other for the use of the potter was not clearly ascertained. Possibly the smaller proportion of silica and larger amount of alumina, iron oxide, &c., have something to do with it. These are good clays for ordinary stone-ware, &c.

MADISON COUNTY COALS.

No. 1877—"*Coal, from Cox's coal bank. Top of Big Hill. Bed forty inches thick. A sub-conglomerate coal. Average sample by A. R. Crandall.*"

A deep-black splint coal, splitting into very thin laminæ, with much fibrous coal and some little pyrites, some of which is in a small shot form.

No. 1878—"*Coal, from M. Moran's mine. Top of Big Hill, on the road. Bed said to be thirty-six to forty-four inches thick. A sub-conglomerate coal. Sample (more sulphurous than usual) brought by Mr. Wm. A. Gunn, Civil Engineer, &c.*"

A pretty pure-looking splint coal, with very little fibrous coal, but considerable fine granular pyrites between the laminæ.

COMPOSITION OF THESE MADISON COUNTY COALS.

	No. 1877.	No. 1878.
Specific gravity	1.281	1.282
Hygroscopic moisture	2.66	1.90
Volatile combustible matters	33.68	45.76
Coke	63.66	52.34
Total	100.00	100.00
Total volatile matters	36.34	47.66
Fixed carbon in the coke	56.16	44.86
Ash	7.50	7.48
Total	100.00	100.00
Character of the coke	Dense spongy.	Dense.
Color of the ash	Nearly white.	Nearly white.
Per centage of sulphur	0.824	2.888

These two samples, from the same bed evidently, present remarkable differences; No. 1878 giving off much more volatile combustible matters, and leaving less carbon in the coke than the other, approaching more nearly to the character of a cannel coal than that. The relative proportions of sulphur are also very different; all illustrating the great variations in composition which may appear between a selected hand specimen and an average sample of the whole bed. The coke obtained from No. 1877 is somewhat dense and fine cellular.

MAGOFFIN COUNTY.

COALS.

No. 1878 (*a*)—"*Salyersville Coal. Lower part; fourteen inches thick. Half cannel. Collected by A. R. Crandall.*"

A sample partly cannel and partly bright bituminous or splint coal. No apparent fibrous coal or pyrites.

No. 1879—"*Salyersville Coal. Upper part; eighteen inches thick. Collected by A. R. Crandall.*"

A pure-looking, pitch-black coal, with very little fibrous coal and no apparent pyrites.

No. 1880—"*Coal, from Amos Davis' bank, on Licking river. Bed forty-four inches thick, with a five-inch parting. Sample by A. R. Crandall.*"

A firm, pitch-black splint coal, with some fibrous coal and fine granular pyrites between its thin laminæ.

No. 1881—"*Coal, from Stacye coal bank, near the mouth of Johnson's Creek. Bed four feet thick, without parting. Average sample from near the outcrop. By A. R. Crandall.*"

A somewhat mixed sample. Mostly bright, pitch-black coal, with some little dull, and seemingly cannel coal.

No. 1882—"*Colvin's Cannel Coal. Bed three feet thick. Average sample from the main outcrop. By A. R. Crandall.*"

Rather a dull-looking cannel coal. Portions showing a somewhat fibrous structure; other portions splitting into thin laminæ. Has very little fibrous coal and no apparent pyrites. Surfaces soiled somewhat with dirt.

COMPOSITION OF THESE MAGOFFIN COUNTY COALS, AIR-DRIED.

	No. 1878*a*.	No. 1879.	No. 1880.	No. 1881.	No. 1882.
Specific gravity	1.275	1.292	1.309	1.270	1.235
Hygroscopic moisture	1.80	2.70	4.34	3.70	2.30
Volatile combustible matters	45.60	38.04	37.36	36.64	51.90
Coke	52.60	59.26	58.30	59.66	45.80
Total	100.00	100.00	100.00	100.00	100.00
Total volatile matters	47.40	40.74	41.70	40.34	54.20
Fixed carbon in the coke	43.40	51.62	53.14	54.68	37.56
Ash	9.20	7.64	5.16	4.98	8.24
Total	100.00	100.00	100.00	100.00	100.00
Character of the coke	Dense spongy.	Light spongy.	Spongy.	Light spongy.	Very dense.
Color of the ash	Buff-grey.	Very light bro'h-grey.	Light purplish-grey.	Light buff-grey.	Brownish-grey.
Per centage of sulphur	0.688	1.470	1.357	0.944	1.415

All of these coals are good, and most of them very good, containing but a moderate or small proportion of ash, and less than the usual quantity of sulphur. The cannel coals, although leaving more ash than the others, would doubtless produce fully as much heat, in equal weights of the coals, because of their larger proportions of hydrocarbons: it being a well-established fact that *hydrogen* will give out three times as much heat as *carbon*, when they are burned in equal weights.

MARTIN COUNTY.

COALS.

No. 1883—"*Coal No.* 1, *from Warfield. Mouth of Collins' Creek. Entry near the salt-works. Average sample from upper four and a half feet bed. By A. R. Crandall.*"

A jet-black, pure-looking coal, breaking into thin laminæ, with some fibrous coal and fine granular pyrites between.

No. 1884—"*Coal. Warfield. Opening in the face of the hill on Tug Fork, three hundred feet above low water. Sample by A. R. Crandall.*"

Aspect of the coal a little more dull than that of the preceding.

No. 1885—"*Warfield Splint Coal. Three hundred and one feet above the main Warfield coal. Bed three feet thick, with two thin clay partings. Sample by A. R. Crandall.*"

Has fibrous coal between the laminæ, but little appearance of pyrites. Some little ferruginous stain on the seams.

No. 1886—"*Eight Feet Coal. Head of Laurel Fork of Nat's Creek. Sample from an old opening. By A. R. Crandall.*"

Rather a dull-looking coal. Has but little fibrous coal and no apparent pyrites between the laminæ. Some little ferruginous stain.

No. 1887—"*Coal No. 1. Warfield. Sample from two rooms. By A. R. Crandall.*"

Generally a glossy, pitch-black splint coal. Has very little fibrous coal, generally, between the laminæ. Some thin scales of brassy pyrites in some of the seams, and occasional layers of fibrous coal with granular pyrites

COMPOSITION OF THESE MARTIN COUNTY COALS, AIR-DRIED.

	No. 1883.	No. 1884.	No. 1885.	No. 1886.	No. 1887.
Specific gravity	1.351	1.358	1.358	1.367	1.302
Hygroscopic moisture	2.16	2.50	2.24	3.50	2.00
Volatile combustible matters	33.60	33.70	33.06	31.94	35.12
Coke	64.24	63.80	64.70	64.56	62.88
Total	100.00	100.00	100.00	100.00	100.00
Total volatile matters	35.76	36.20	35.30	35.44	37.12
Fixed carbon in the coke	55.06	52.62	52.70	52.06	54.82
Ash	9.18	11.18	12.00	12.50	8.06
Total	100.00	100.00	100.00	100.00	100.00
Character of the coke	Light spongy.	Light spongy.	Dense.	Dense.	Dense.
Color of the ash	Brownish-grey.	Light lilac-grey.	Very light lilac-grey.	Very light lilac-grey.	Lilac-grey.
Per centage of sulphur	2.563	0.754	0.604	0.873	0.983

These Martin county coals generally contain rather more than the average amount of earthy matters, but less than the usual quantity of sulphur. Their rather large proportion of ash, however, does not materially detract from their value for use in manufacturing processes, or for fuel.

M'LEAN COUNTY.

No. 1888—"BITUMINOUS SHALE (*so-called cannel coal*), *from near Wrightsburg. Collected by C. J. Norwood.*"

A somewhat tough, dull-looking bituminous shale. Some ferruginous stain on the exposed surfaces.

No. 1889—"COAL, *from near Wrightsburg. Average sample by C. J. Norwood.*"

A jet-black, splint coal, with very little friable fibrous coal and granular pyrites between some of the thin laminæ.

COMPOSITION, AIR-DRIED.

	No. 1888.	No. 1889.
Specific gravity	not det'd.	1.241
Hygroscopic moisture	1.60	3.30
Volatile combustible matters	36.40	36.00
Coke	62.00	60.70
Total	100 00	100.00
Total volatile matters	38.00	39.30
Carbon in the coke	31.36	57.88
Ash	30.64	2.82
Total	100.00	100.00
Character of the coke	Friable.	Light spongy.
Color of the ash	Brownish lilac-grey.	Buff-grey.
Per centage of sulphur	not est.	1.024

The coal No. 1889 is remarkably pure and good. The bituminous shale or impure cannel coal might, in many cases, be profitably used as fuel, notwithstanding its large ash per centage.

MORGAN COUNTY.

COALS.

No. 1890—"*Pierat's Cannel Coal. Collected by A. R. Crandall.*"

A tough, somewhat dull-looking coal, breaking with difficulty into thin laminæ. Has a satiny lustre on its cross fracture. Contains no apparent pyrites or fibrous coal. The sample is mixed with a little attached brittle, glossy, splint coal.

No. 1891—"*Cannel Coal, from Maynhier's bank. Elk Fork of Licking river. Layer of cannel coal two feet two inches thick. Collected by A. R. Crandall.*"

A dull-black, clean-looking coal. Fracture somewhat fibrous across the laminæ. No fibrous coal or apparent pyrites.

No. 1892—"*Six-foot Coal. Near West Liberty. Collected by A. R. Crandall.*"

A soft splint coal, breaking into thin laminæ, with fibrous coal between, but no apparent pyrites.

COMPOSITION OF THESE MORGAN COUNTY COALS, AIR-DRIED.

	No. 1890.	No. 1891.	No. 1892.
Specific gravity	1.230	1.331	1.353
Hygroscopic moisture	2.06	2.30	4.26
Volatile combustible matters	49.64	41.60	35.24
Coke	48.30	56.10	60.50
Total	100.00	100.00	100.00
Total volatile matters	51.70	43.90	39.50
Fixed carbon in the coke	43.20	44.70	50.10
Ash	5.10	11.40	10.40
Total	100.00	100.00	100.00
Character of the coke	Spongy.	Very dense spongy.	Dense spongy.
Color of the ash	Light buff-grey.	Grey-buff.	Nearly white.
Per centage of sulphur	0.955	1.271	1.011

Cannel coal No. 1890 is remarkably pure and good; the others contain more than the average quantity of earthy matters, yet are profitable coals.

MEADE COUNTY.

No. 1893—"SALT WATER, *fresh from the well. Glen Font Salt-works. Collected by C. J. Norwood.*"

The water deposits a reddish sediment in the bottle, and gives an alkaline reaction after a time.

SPECIFIC GRAVITY OF THE WATER = 1.065.

COMPOSITION OF THE WATER IN 1000. PARTS.

Iron and manganese oxides, alumina and phosphoric acid,	0.055	Contained in the sediment deposited on boiling.
Lime carbonate	.654	
Magnesia carbonate	.018	
Silica	.005	
Sodium chloride	74.750	
Potassium chloride	.250	
Calcium chloride	9.050	
Magnesium chloride	2.080	
Barium chloride	.036	
Strontium chloride	.026	
Lithium chloride	.284	
Bromides and iodides	not est.	
Soluble silica	not est.	
	87. 208	

This brine, like that of the Goose Creek Salt-works, in Clay county (which see), contains notable quantities of barium and strontium chlorides; and as the former salt is considered injurious to the animal economy, it is well to get rid of it in the manufacture of the salt. This is easily to be done, as described under the head of the Goose Creek Salt-works.

One thousand parts of the water evaporated to dryness left a little more than one hundred parts of saline matters, dried at 212° F. The difference between that amount and the sum of the solid ingredients given in the analysis is doubtless owing to moisture, the undetermined ingredients, and unavoidable loss.

No. 1894—"THE BITTERN WATER, *from the Glen Font Salt-works.*"

The water has a slightly brownish color.

Specific gravity = 1.270.

This water, analyzed by my son, Alfred M. Peter, gave the following results:

COMPOSITION IN 100. PARTS.

Sodium chloride	3.206
Potassium chloride	.553
Calcium chloride	12.043
Magnesium chloride	13.314
Lithium chloride	.658
Barium chloride	.096
Strontium chloride	.147
Copper chloride	.008
Iodine	.002
Bromine	.382
Total	30.409

The trace of copper is doubtless due to the copper pipes, &c., in contact with the water. The proportion of lithium chloride is considerable. Whether there is enough bromine in it for profitable extraction depends on commercial and other circumstances.

Remarks on other probable useful applications of the bittern waters of salt-works will be found under the head of Goose Creek Salt-works, Clay county; also under the head of Grayson county marls.

With these samples there came a specimen of the "*salt water from the first settler*," which also had a brownish tint, and deposited a brownish sediment in the bottle.

Its *specific gravity* was 1.205, and it contained nearly twenty-six per cent. of dry saline matters.

Also "*water from the Grainer*," which had crystals of salt at the bottom. *Specific gravity* = 1.210.

It gave a little more than twenty-four per cent. of dried saline matters on evaporation, and was found to contain iodine equal to 0.009 per cent. of potassium iodide.

No. 1895—"SALT, *manufactured from the Glen Font brine. Collected by C. J. Norwood.*"

A moderately coarse-grained salt. Slightly damp with bittern water. Of a very light pinkish tint in the mass, from the presence of a little of the red sediment.

COMPOSITION, DRIED AT 212° F.

Sodium chloride (common salt) with traces of potassium and lithium chlorides	97.317
Calcium chloride	1.235
Magnesium chloride	1.415
Barium and strontium chlorides	traces only.
Insoluble residue (remains of red sediment)	.033
Total	100.000

This may be considered quite a pure salt as compared with the usual products of our salt-wells. The *traces* of barium salt are too small to be injurious; nor is the residue of red sediment injurious. The deliquescent salts, calcium, and magnesium chlorides, keep the salt always moist; they are said also to injure its antiseptic properties somewhat. These are easily removed by the addition of a little carbonate of soda—soda ash will do—which will precipitate lime and magnesia carbonates, and leave an equivalent of sodium chloride in solution. Thus purified, in the last operation before graining, the resulting salt would be perfectly dry and white and pure.

In addition to the above-described samples, the following were also received and examined from these salt-works, viz:

(*a*)—"*The hard red crust formed around the steam-pipe, where the heat is not great.*" (*A rather indefinite description.*)

This crust, of a handsome orange-red color in the interior and brown on the exterior, having a radiated fibrous structure, dissolved in chlorohydric acid with effervescence; and was found to consist mainly of lime, iron, and magnesia carbonates, &c.

(*b*)—"*The sediment formed inside the copper pipes conveying steam into the salt water.*"

A greenish-white, fibrous crust (colored thus slight by the action of the water on the copper), mainly made up of hexagonal prisms of lime carbonate. *An artificially formed* aragonite.

Testing showed no evidence of strontium in it, and only a trace of magnesium. The crystals, under the microscope,

appear beautifully transparent and colorless. The crust has the external form of the interior of the pipe, and is somewhat impregnated with the soluble salts of the water.

(*c*)—"*The sediment from the bottom of the settler.*"

A yellowish-brown mud, containing saline matters. When these were washed out the insoluble residue was found to consist mainly of lime carbonate and a little magnesia carbonate, colored with iron oxide.

These samples were all collected by C. J. Norwood.

MENIFEE COUNTY.

COALS.

No. 1896 (*a*)—"*Coal, from Price and Fitch's bank. Top of the mountain. Bed thirty-four inches thick. Sample from the coal yard of Richardson and Bosworth, Lexington.*"

A bright splint coal, breaking with difficulty across the laminæ; easily in their direction. Some reedy fibrous coal and bright thin pyritous plates between them.

No. 1896 (*b*)—"*Coal, from Adams' bank, near Frenchburg. Old Slate Branch. Average Sample collected by A. R. Crandall.*" *In the Sub-carboniferous limestone.*

A very pure-looking coal; glossy, pitch-black. Has very little fibrous coal or pyrites.

No. 1896 (*c*)—"*Coal. Old State Road Branch. Sample from the stock pile. By A. R. Crandall.*"

A very pure-looking, glossy, deep pitch-black coal. Very little fibrous coal or pyrites apparent.

No. 1896 (*d*)—"*Coal, from Steele's bank. Mouth of Brushy Fork of Beaver Creek. Collected by A. R. Crandall.*"

A pitch-black splint coal; not so glossy or black as 1896(*b*). Has some fine pyrites and fibrous coal between the laminæ.

COMPOSITION OF THESE MENIFEE COUNTY COALS, AIR-DRIED.

	No. 1896 *a*.	No. 1896 *b*.	No. 1896 *c*.	No. 1896 *d*.
Specific gravity	1.300	1.300	1.318	1.301
Hygroscopic moisture	5.00	5.00	2.70	3.80
Volatile combustible matters	39.06	32.40	38.22	38.60
Coke	55.94	62.60	59.08	57.60
Total	100.00	100.00	100.00	100.00
Total volatile matters	44.06	37.40	40.92	42.40
Fixed carbon in the coke	53.18	58.40	54.82	52.00
Ash	2.76	4.20	4.26	5.60
Total	100.00	100.00	100.00	100.00
Character of the coke	Spongy.	Dense.	Spongy.	Light spongy.
Color of the ash	Brownish-lilac-grey.	Light yellowish-grey.	Lilac-grey.	Brownish-lilac-grey.
Per centage of sulphur	1.199	0.614	1.615	2.095

These are all remarkably good coals, containing less than the average of earthy matters, as well as of sulphur.

No. 1897—"LIMONITE IRON ORE. *Branch of Beaver Creek. Menifee county. Average sample by P. N. Moore.*"

COMPOSITION, DRIED AT 212° F.

Iron peroxide	54.750	= 38.750 per cent. of iron.
Alumina	14.517	
Manganese oxide	not est.	
Lime carbonate	a trace.	
Magnesia	.047	
Phosphoric acid	.697	= .304 phosphorus.
Sulphuric acid	a trace.	
Combined water	8.600	
Silicious residue	20.830	Containing 19.300 silica.
Loss	.559	
	100.000	

This is quite a good iron ore, with an average proportion of phosphoric acid, which will not injure it for all ordinary iron production. Its considerable proportion of alumina may help

to carry off much of this injurious ingredient in the furnace slag or cinder.

MUHLENBURG COUNTY.

COALS.

No. 1898—"*Coal B, from the Louisville and Stroud City mines. Owensboro Junction. 'Gas coal;' sixteen inches thick; at the top of the bed. Collected by C. J. Norwood.*"

A bright jet-black coal, with very little fibrous coal or pyrites apparent.

No. 1899—"*Coal B, from the same mine. Bed three to four feet thick. Owensboro Junction. Sample by C. J. Norwood.*"

A pitch-black, glossy coal. Has some fibrous coal and fine granular pyrites between some of the laminæ, and thin, bright pyritous and gypseous scales in some of the seams.

No. 1900—"*Coal B, from the Memphis Coal Company's mine, four miles south of Owensboro Junction, E., O. & N. R. R. From stock pile; probably from the top of the bed. Has been weathered for eighteen months, and is not a fair sample. Collected by C. J. Norwood.*"

A pitch-black coal, with but little fibrous coal or pyrites apparent.

No. 1901—"*Coal B. Bed four feet four inches to four feet eight inches thick. Saint Louis mines. Owensboro Junction. Sample by C. J. Norwood.*"

A pitch-black coal. Has some fibrous coal, and a few shining pyritous scales.

No. 1902—"*Coal B. Same mine as the next preceding. The 'gas coal;' sixteen inches thick. Collected by C. J. Norwood.*"

A pure-looking pitch-black coal. Has very little fibrous coal and no apparent pyrites.

No. 1903—"*Coal B. Rothrock's coal mine, a mile and a half north of Owensboro Junction. Upper bench; three feet nine inches thick. Average sample by C. J. Norwood.*"

Generally a pitch-black, glossy coal, with but little fibrous coal, &c., but the sample contained portions of an inch thick pyritous layer, weighing about nine per cent. of the whole, which was separated from the coal analyzed and examined separately (see 1903 *a*).

COMPOSITION OF THESE MUHLENBURG COUNTY COALS, AIR-DRIED.

	No. 1898	No. 1899	No. 1900	No. 1901	No. 1902	No. 1903
Specific gravity	1.280	1.309	1.313	1.235	1.307	1.332
Hygroscopic moisture	4.60	3.36	5.40	5.40	4.60	3.80
Volatile combustible matters	42.60	37.90	35.90	34.20	37.60	36.20
Coke	52.80	58.74	58.70	60.40	57.80	60.00
Total	100.00	100.00	100.00	100.00	100.00	100.00
Total volatile matters	47.20	41.26	41.30	39.60	42.20	40.00
Fixed carbon in the coke	50.06	52.74	53.60	54.20	52.64	51.80
Ash	2.74	6.00	5.10	6.20	5.16	8.20
Total	100.00	100.00	100.00	100.00	100.00	100.00
Character of the coke	Spongy.	Light spongy.	Light spongy.	Light spongy.	Light spongy.	Light spongy.
Color of the ash	Light grey.	Light lilac-grey.	Light lilac-grey.	Bright lilac-grey.	Dark brown-ish-grey.	Lilac-grey.
Per centage of sulphur	1.601	2.686	2.219	3.136	2.372	3.194

No. 1903 (*a*)—The *pyritous shale*, separated from the general sample as above stated, left on incineration 65.90 per cent. of its weight of red-brown ash. It contained 27.64 per cent. of its weight of sulphur. If it had been left in the sample it would have increased the *ash* per centage of the whole to 13.394 per cent., and the *sulphur* per centage of the whole to 5.410 per cent. It was probably only accidentally present in the sample. This pyritous layer would certainly be rejected in preparing the coal for the market.

MUHLENBURG COUNTY SOILS.

No. 1903 (*a*)—"*Virgin Soil, from the farm of A. Stroud, twenty-seven miles from Owensboro. Collected by C. W. Beckham.*"

A clay soil, generally in lumps, breaking of a light bluish-grey color, with ferruginous infiltrations. Contains a small proportion of fine iron gravel. The bolting-cloth removed from the silicious residue a small quantity of small rounded grains of reddish and hyaline quartz.

No. 1903 (*b*)—"*Subsoil of the preceding*," *&c.*

Dried soil somewhat lighter colored than the preceding; contains rather more of rounded ferruginous concretions. The silicious residue contained some fine rounded quartzose grains.

No. 1903 (*c*)—"*Surface Soil, from a field about thirty years in cultivation; in grass all the time except for the last four years, when it was in corn and small grain. Underlying rock; sandy shale. Collected by C. W. Beckham.*"

Dried soil of a light, buff-grey color; contains some few ferruginous sandy concretions. The bolting-cloth separated from the silicious residue a considerable proportion of small rounded, clear and reddish quartz and silicate grains.

COMPOSITION OF THESE MUHLENBURG COUNTY SOILS, DRIED AT 212° F.

	No. 1903 *a*.	No. 1903 *b*.	No. 1903 *c*.
Organic and volatile matters	3.325	1.052	1.242
Alumina and iron and manganese oxides	4.137	3.548	3.749
Lime carbonate	.345	.006	.145
Magnesia	.176	.167	.122
Phosphoric acid	.198	.102	.121
Sulphuric acid	a trace.	a trace.	a trace.
Potash	.145	.167	.255
Soda	not est.	not est.	.477
Sand and insoluble silicates	90.215	94.340	93.140
Water, expelled at 380° F.	1.222	1.050	1.242
Total	99.763	100.432	100.493
Hygroscopic moisture	1.800	0.775	0.965
Potash in the insoluble silicates	1.339	1.091	1.113
Soda in the insoluble silicates	.716	.564	.474
Character of the soil	Virgin soil.	Old field soil.	Subsoil.

Soils of good average quality.

OHIO COUNTY.

COALS.

No. 1904—"*Coal D, from McHenry coal mine. McHenry Station. This sample does not include the 'sulphur band.' Collected by C. J. Norwood.*"

Quite a handsome, pitch-black, glossy coal. Has some fibrous coal between some of the laminæ, with granular pyrites, and some thin pyritous scales in the seams.

No. 1905—"*Coal D. Same locality as the preceding. This sample includes the 'sulphur band.' Collected by C. J. Norwood.*"

No. 1906—"*Coal D, from Render mine. Hamilton Station. Sample from the nut coal pile. Collected by C. J. Norwood.*"

A pure-looking, glossy-black coal; somewhat soft. Has very little fibrous coal, and no apparent pyrites. Some thin incrustation of gypsum in the seams.

No. 1907—"*Coal D, from same locality as next preceding. Sample from the slack pile. By C. J. Norwood.*"

No. 1908—"*Coal, from Charles Wesley Stephens'. On Rough Creek, above Hartford. Collected by C. J. Norwood.*"

A bright, pitch-black coal, breaking easily into irregular layers. Fracture often in natural joints, showing a coarse, irregular fibrous structure on surfaces. Contains but little fibrous coal. Some pieces show some thin scales of bright pyrites and gypsum.

No. 1909—"*Coal, from G. B. Hocker's coal bank. On Rough Creek, about four and a half miles above Hartford. Collected by C. J. Norwood.*"

Resembles the preceding; has fewer irregular seams, more fibrous coal, and fewer pyritous scales. Exterior with ferruginous stain.

No. 1910—"*Coal, from same locality as the next preceding,*" *&c., &c.*

Resembles the preceding, but is brighter and has less pyrites, &c. A very pure-looking coal. Some exterior ferruginous incrustation.

No. 1911—"*Coal, from Marion Sandifer's coal bank. Big Muddy Creek, one mile southwest from Elm Creek. Sampled from near the outcrop. May not be a fair sample of the bed. Collected by C. J. Norwood.*"

A dull-looking splint coal, with but little fibrous coal between the laminæ. Apparently weathered. Somewhat soiled with dirt, which will increase the apparent ash per centage. Sample also contains some bituminous shale, which will exert the same influence in the analysis. Not much apparent pyrites.

No. 1912—"*Coal, from L. M. Patterson's mine. Point Pleasant. Collected by C. J. Norwood.*"

A splint coal of irregular appearance. Portions are pitch-like; others are quite shaly. (Excluded from the sample a lump which seemed to be a portion of a pyritous parting.)

No. 1913—"*Coal D, from Williams' coal bank. On Ben's Lick. Point Pleasant road. Collected by C. J. Norwood.*"

Resembles the preceding; not much of it pitch-like on the cross fracture. Shows some scales of bright pyrites and some of gypsum. Not much fibrous coal present.

No. 1914—"*Bituminous Shale (so-called cannel coal). H. D. Bennett's coal bank; three miles north of Hartford. A lower coal? Collected by C. J. Norwood.*"

A dull, brownish-black, tough bituminous shale; in thin adherent laminæ, the cross-fracture of which is jet-like. Some exterior earthy stain.

No. 1915—"*Coal, from Berry and Walker's land. Head waters of North Fork of Muddy Creek, four miles east of Hartford, near Ben Hines' coal bank. At the old opening, first above the bank at Stanton Baltzel's. Probably not a fair average sample. Collected by C. J. Norwood.*" (*See No.* 1922.)

Much ferruginous and earthy incrustation on the exterior. Fracture bright, pitch-like. Very little appearance of fibrous coal, but some of pyrites. It seems to be a pure coal, with less lamination than ordinary splint coal.

No. 1916—"*Coal, from Bill Hines' coal bank, four miles east from Hartford. Sample from above the clay parting. By C. J. Norwood.*"

A bright, generally pitch-like coal, with some little fibrous coal, but with little appearace of pyrites between the laminæ. Not so much laminated as ordinary splint coal. Some ferruginous stains in the seams.

No. 1917—"*Coal, from the same bank. Sample from below the clay parting. By C. J. Norwood.*"

Resembles the next preceding; but more of it cleaves into thin laminæ, with fibrous coal between.

No. 1918—"*Coal E. On Rough Creek; mouth of Brush Creek; three miles below Hartford. Collected by C. J. Norwood.*"

A splint coal, mostly splitting into very thin laminæ, with reedy or dull-looking fibrous coal between. Very little appearance of pyrites. Some of the thin laminæ are pitch-like on the cross-fracture. Ferruginous and earthy stain on the exterior surfaces.

No. 1919—"*L. D. Taylor's Coal. Collected by C. J. Norwood.*"

A firm splint coal, splitting into pretty thin laminæ, with fibrous coal and some fine granular pyrites between. Some little bright pyritous scales in the seams.

No. 1920—"*Coal D, from Brown's coal bank, three miles south 40° west from Hartford. Taken from an entry where pyrites were abundant. By C. J. Norwood.*"

Some portions pitch-like; others dull. Generally separating into thin laminæ, with fibrous coal between. Bright pyritous scales and some scales of gypsum in the seams.

No. 1921—"*William Warden's Coal; near the roadside, about half a mile northwest from Centretown. From a heap, and consequently may not be an average sample. Coal covered. C. J. Norwood.*"

A rather firm coal. Some portions pitch-like. Some fibrous coal and granular pyrites between the laminæ.

No. 1922—"*Coal, from Berry and Walker's land. Hines' tract; in a ravine draining into North Fork of Muddy Creek. Sample from the lower two feet. An outcrop sample. By C. J. Norwood.*"

A splint coal, mostly splitting into thin laminæ; generally dull, with some pitch-like layers. Much fibrous coal-dust in the sample.

No. 1923—"*Coal, from A. Woodward's coal bank, on Barrett's Creek. Bed twenty-four to thirty inches thick. A low coal. By C. J. Norwood.*"

Sample evidently from an outcrop, considerably soiled with ferruginous dirt. Coal easily broken and split into quite thin laminæ, some of which present tarnished irised colors. Contains much fibrous coal and bright pyrites.

No. 1924—"*Coal, from Gaines' bank, near Fordsville. Bed four feet thick. Average sample by C. J. Norwood.*"

A firm splint coal, some of it pitch-like on the cross-fracture. Not much fibrous coal, but considerable fine granular pyrites. Some external ferruginous stain.

No. 1925—"*Coal, from H. Dooring's mine. About four miles east from Point Pleasant. Lower member four feet five inches thick. Collected by C. J. Norwood.*

A bright, pitch-black, firm coal, handsomely iridescent on some of the seams. Has very little fibrous coal and some fine granular pyrites between the laminæ.

No. 1926—"*Coal, from Henry Thompson's coal bank. One and three quarters of a mile from Elm Lick. A lower coal (H?). Sample from below the parting, three feet five inches thick. The whole bed, including the parting, four feet ten inches. Collected by C. J. Norwood.*"

A pitch-black coal, in very thin laminæ, with much fibrous coal of a reedy appearance. No apparent pyrites.

No. 1927—"*Coal, from Morton's coal bank, two miles northwest from Centretown. Bed from eight to nine feet thick, with a thin clay parting. Sample from the lower member four feet four inches to four feet seven inches thick. By C. J. Norwood.*"

A pitch-black, pure-looking coal. Iridescent on some of the seams. Not easily breaking into thin laminæ, with very little fibrous coal. Some pyritous and gypsum scales in the seams.

No. 1928—"*Coal, from Martin's coal bank, near Elm Lick. Coal H? From the lower member; not a fair sample, as it is from a new opening just begun. C. J. Norwood.*"

In quite thin laminæ, with fibrous coal and some granular pyrites between. Seems to have been much weathered. Is much stained with ferruginous clayey matter.

No. 1929—"*Coal, from Henry Davis' mine, about four miles east from Point Pleasant. Sample from the upper member three feet nine inches thick. By C. J. Norwood.*"

A pure-looking, pitch-black, firm coal. Not all easily breaking into thin laminæ. Has some fibrous coal and granular pyrites.

COMPOSITION OF THESE OHIO COUNTY COALS, AIR-DRIED.

	No. 1904.	No. 1905.	No. 1906.	No. 1907.	No. 1908.	No. 1909.	No. 1910.	No. 1911.	No. 1912.	No. 1913.	No. 1914.	No. 1915.	No. 1916.
Specific gravity	1.318	1.331	1.310	1.336	1.295	1.297	1.251	1.382	1.386	1.345	1.593	1.273	1.305
Hygroscopic moisture	3.80	2.70	4.40	4.10	5.00	5.90	5.54	5.10	4.80	3.50	2.20	5.30	6.54
Volatile combustible matters	36.66	35.24	38.20	34.36	36.74	33.80	35.66	30.70	33.70	36.30	27.80	45.70	37.92
Coke	59.54	62.06	57.40	61.54	58.26	60.30	58.80	64.20	61.50	60.20	70.00	49.00	55.54
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Total volatile matters	40.46	37.94	42.60	38.46	41.74	39.70	41.20	35.80	38.50	39.80	30.00	51.00	44.46
Fixed carbon in the coke	52.00	53.62	49.94	51.24	55.66	56.90	56.20	54.24	52.26	50.92	35.28	45.00	51.54
Ash	7.54	8.44	7.46	10.30	2.60	3.40	2.60	9.96	9.24	9.28	34.72	4.00	4.00
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Character of the coke	Spongy.	Light spongy.	Light spongy.	Light spongy.	Light spongy.	Light spongy.	Light spongy.	Spongy.	Spongy	Light spongy.	Pulverulent.	Dense spongy.	Light spongy.
Color of the ash	Light lilac-grey.	Lilac-grey	Light lilac-grey.	Lilac-grey	Light brown.	Buff.	Light buff.	Light brownish lilac-grey.	Brownish lilac-grey.	Brownish lilac-grey	Dark brownish lilac-grey.	Lilac-grey	Light yellowish-brown.
Per centage of sulphur	1.944	3.785	2.246	3.263	1.605	1.038	0.983	2.164	3.364	3.524	5.694	2.150	1.917

COMPOSITION OF THESE OHIO COUNTY COALS, AIR-DRIED—(Continued).

	No. 1917.	No. 1918.	No. 1919.	No. 1920.	No. 1921.	No. 1922.	No. 1923.	No. 1924.	No. 1925.	No. 1926.	No. 1927.	No. 1928.	No. 1929.
Specific gravity	1.295	1.384	1.340	1.356	1.357	1.380	1.413	1.310	1.310	1.282	1.348	1.321	1.411
Hygroscopic moisture	4.80	4.80	6.80	4.80	6.66	6.00	2.70	6.10	5.54	3.96	3.94	3.70	3.20
Volatile combustible matters	41.00	35.80	32.40	35.60	33.64	34.30	39.30	37.50	35.66	40.50	37.86	36.64	37.06
Coke	54.20	59.40	60.80	59.60	59.70	59.70	58.00	56.40	58.80	55.54	58.20	59.66	59.74
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100 00	100.00	100.00	100.00	100.00	100.00
Total volatile matters	45.80	40.60	39.20	40.40	40.30	40.30	42.00	43.60	41.20	44.46	41.80	40.34	40.26
Fixed carbon in the coke	49.14	45.20	52.50	49.66	51.56	50.36	45.90	50.46	48.88	52.38	50.48	55.30	47.24
Ash	5.06	14.20	8.30	9.94	8.14	9.34	12.10	5.94	9.92	3.16	7.72	4.36	12.50
Total	100.00	100.00	100.00	100 00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Character of the coke	Light spongy.	Spongy.	Spongy.	Spongy.	Light spongy.	Spongy.	Spongy.	Spongy.	Much inflated.	Much inflated.	Light spongy.	Dense.	Dense.
Color of the ash	Dark lilac-grey.	Light lilac-grey.	Very light lilac-grey.	Light lilac-grey.	Light grey.	Grey-brown.	Greyish purplish-brown.	Light grey.	Dark lilac-grey.	Lilac-grey.	Lilac-grey.	Light purplish-brown.	Dark lilac-grey
Per centage of sulphur	2.356	3.015	2.109	3.180	2.768	4.307	7.959	3.002	4.199	1.407	3.128	1.241	6.809

These Ohio county coals are generally good, and some of them are very good; the ash and sulphur per centages of some of them, it will be seen, exceed the average; but none, except the one characterized as bituminous shale, is very seriously injured for all ordinary applications: even this might be utilized as fuel in its own vicinity.

The general correspondence between the specific gravity and ash per centage is still further exhibited in these analyses.

OHIO COUNTY LIMONITE IRON ORES.

No. 1930—"*Limonite Ore, from Alfred Ashby's land, on the waters of Walton Creek. Seems to be slightly magnetic? Collected by C. J. Norwood. Coal measures.*"

A porous, cellular, somewhat friable ore; generally of a deep-brown color, with blotches and thin laminæ of light ochreous and irregular portions of denser, fine granular, or specular ore, of a steel-blue color, which is slightly magnetic and gives a red streak.

No. 1931—"*Limonite, from Dooring's iron bank. Coal measures. Sampled for analysis by C. J. Norwood.*"

Composed of irregular laminæ; generally of a dark-brown color, with lighter, ochreous ore mixed and incrusting. Somewhat friable. Powder of a handsome bright yellow-ochre color.

No. 1932—"*Limonite, from same locality as preceding,*" *&c. &c.*

Resembles the preceding. Probably a little more dense.

No. 1933—"*Ochreous Limonite, from Mrs. Kate Inglehart's place, eight miles southwest of Hartford. Coal measures. Collected by C. J. Norwood.*"

A fine granular, friable ochre, of a handsome brownish-yellow color.

COMPOSITION OF THESE OHIO COUNTY LIMONITE IRON ORES, DRIED AT 212° F.

	No. 1930.	No. 1931.	No. 1932.	No. 1933.
Iron peroxide	75.845	55.357	56.972	18.676
Alumina	.837	9.656	1.148	2.481
Manganese oxide	not est	not est.	not est.	not est.
Lime carbonate	a trace.	a trace.	a trace.	a trace.
Magnesia	.176	.248	.176	.338
Phosphoric acid	.648	.287	.280	.073
Sulphuric acid	not est.	not est.	not est.	not est.
Combined water	9.273	8.860	8.920	6.152
Silicious residue	13.830	26.550	32.504	72.280
Total	100.609	100.958	100.000	100.000
Iron per centage	53.091	38.750	39.880	13.073
Phosphorus per centage	.283	.125	.177	.032
Sulphur per centage	not est.	not est.	not est.	not est.
Silica per centage	9.960	23.420	24.460	69.100

No. 1930 is a good iron ore, containing not more than the average proportion of phosphorus, which may be partly removed, in smelting, in combination with its large proportion of alumina, if sufficient lime be employed as the flux. Nos. 1931 and 1932, although containing much less iron, may be made available in mixture with other richer ores. But No. 1933 is too poor for iron production, and could only be employed as a pigment, or in mixture with very rich ores, to furnish silicious matter to aid in fluxing them.

OWEN COUNTY.

No. 1934—"GALENA, *from a vein about twenty-three inches thick, on Twin Creek. Sent by Thos. J. Jenkins, Esq., New Liberty.*"

A digging has been made more than eighty feet deep, and the vein gradually widens as it descends. The specimen sent was obtained about five feet below the surface. *Lower Silurian formation.*

The galena has some little zinc blende mixed with it, and has a gangue of baryta sulphate and calcareous spar (lime carbonate). It contains, of course, the usual per centage of lead, being a definite chemical compound of lead and sulphur; and, if found in sufficient quantities in the vein, for the

cheap production of lead, would be valuable; but in this region, where galena is very frequently found, mixed in large or small (but generally small) proportion with the baryta sulphate, which forms numerous veins in our "blue limestone," the prevalent idea is that there is a large quantity of silver in this shining ore. Indeed, companies have been formed, and much capital sunk in the opening and working of so-called silver mines in the baryta veins of our Lower Silurian limestone; with the usual result, that even the lead obtained and the spar sold would not repay the cost of the labor, while silver is not found.

The specimen above described was examined carefully for the presence of silver, in the wet way, with the result that no ponderable quantity of that metal could be separated from it. This has been the usual result of the analyses of the galenas of this region. They all appear to be remarkably poor in silver. The only practical question in relation to these metallic veins seems, therefore, to be, whether they can be profitably worked for the lead alone. The baryta sulphate, which is quite abundant in these veins, has not yet found a profitable application in any quantity.

No. 1935—"BARYTA SULPHATE; *massive.* (*Ponderous spar.*) *From the same locality as the above. Hunter's Mill. Twin Creek. Collected by C. J. Norwood.*"

This spar was analyzed by my son, Alfred M. Peter, mainly for the purpose of determining the proportion of strontium contained in it, with the following result:

COMPOSITION, DRIED AT 212° F.

Baryta sulphate	80.31
Strontia sulphate	17.05
Lime sulphate	.34
Iron peroxide	.15
Silica	.29
Loss, &c., &c.	1.86
Total.	100.00

The proportion of strontia sulphate is larger than was supposed. The presence of strontium in this spar corresponds

with its existence in association with barium in some of the saline waters of our State, as shown under the head of Clay and Meade counties in the present report.

OWSLEY COUNTY.

COALS.

No. 1936—"*Coal, from the mines of Steffee & Samuel. South Fork of Kentucky river, four miles above Boonesville, on the east bank of the river. Sample sent by Mr. J. T. Steffee, and analyzed at the request of the Governor. Bed three feet thick.*"

A good-looking splint coal. Iridescent on some of its surfaces; containing some bright pyritous scales, and showing marked reedy impressions on some of the laminæ.

No. 1937—"*Cannel Coal, owned by Steffee & Samuel. South Fork of Kentucky river,*" *&c., &c.* (*as above*).

A handsome cannel coal. Very tough. Jet-black and glossy on its cross fracture. Has no apparent pyrites.

COMPOSITION OF THESE OWSLEY COUNTY COALS, AIR-DRIED.

	No. 1936.	No. 1937.
Specific gravity	1.294	1.161
Hygroscopic moisture	2.10	0.50
Volatile combustible matters	35.24	59.70
Coke	62.66	39.80
Total	100.00	100.00
Total volatile matters	37.34	60.20
Fixed carbon in the coke	58.66	32.34
Ash	4.00	7.46
Total	100.00	100.00
Character of the coke	Spongy.	Dense.
Color of the ash	Light lilac-grey.	Light brown.
Per centage of sulphur	1.424	not det'd.

These coals are both remarkably good and pure of their kinds. The cannel coal exceeds the celebrated Haddock's cannel coal in volatile matters fully ten per cent., and equals the Breckinridge coal of Hancock county in its volatile combustible matters (see No. 1813, Cloverport Oil Company's coal), than which it has a smaller ash per centage. It greatly resembles this celebrated coal, but is purer. Should our petroleum wells run low, coals of this character will be again profitably available for the production of so-called coal oil, lubricating oils, and other paraffins, with the lighter hydrocarbons, now derived almost exclusively from the mineral oil. A greater economy in the manufacture of these from the cannel coal, and the profitable use of the gas and coke, which are simultaneously produced, may favor the competition of the coal distillates with those from the petroleum.

PERRY COUNTY.

COALS.

No. 1938—"*Coal, from Josiah Cobb's bank, near Hazard. Average sample taken from the upper part of the bed, the lower part not being uncovered. By P. N. Moore.*"

A pure, pitch-black splint coal, having very little fibrous coal between the laminæ, but with ferruginous stain and appearance of pyrites in parts.

No. 1939—"*Coal, from Campbell's bank. Mace's Creek. Sampled from near the outcrop; hence probably will give more ash than the coal further in. Collected by P. N. Moore.*"

A splint coal, very much weathered and soiled with dirt; hence the ash per centage is probably greater than that of the bed. The sample has much powdered (fibrous) coal in it; probably more than belongs to it.

No. 1940—"*Coal, from R. C. Combs' bank; below Hazard, on the North Fork of Kentucky river. Collected by P. N. Moore.*"

A pure-looking, pitch-black splint coal. Has some ferruginous stain on some of its seams, but very little fibrous coal or apparent pyrites.

No. 1941—"*Coal, from Logan's drift. Brashear Salt-works. Collected by P. N. Moore.*"

Resembles the preceding, but has no ferruginous stain.

No. 1942—"*Coal, from David Grigsby's bank. Lot's Creek. Bituminous coal, above the cannel coal. Collected by P. N. Moore.*"

Coal, breaking into thin laminæ, with but little fibrous coal or granular pyrites between them. Exterior of the lumps dull and much stained with ferruginous and clayey matters, as though they had been weathered, which probably may somewhat increase the ash per centage.

No. 1943—"*Coal, from the same bed as the next preceding. Lower part of the bed. The cannel coal. Collected by P. N. Moore.*"

Mostly tough, compact cannel coal, with a satiny lustre on its cross-fractured surfaces. Some pieces more readily separate into thin laminæ. The exterior surfaces are soiled with ferruginous and clayey matters, which will probably make the apparent ash per centage greater than that of the clean coal of the beds.

COMPOSITION OF THESE PERRY COUNTY COALS, AIR-DRIED.

	No. 1938	No. 1939	No. 1940	No. 1941	No. 1942	No. 1943
Specific gravity	1.289	1.370	1.303	1.288	1.274	1.290
Hygroscopic moisture	2.10	3.70	2.06	1.60	1.80	1.20
Volatile combustible matters	36.20	30.64	36.74	36.10	40.90	40.86
Coke	61.70	65.66	61.20	62.30	57.30	57.94
Total	100.00	100.00	100.00	100.00	100.00	100.00
Total volatile matters	38.30	34.34	38.80	37.70	42.70	42.06
Fixed carbon in the coke	58.20	57.02	56.30	56.40	53.70	48.44
Ash	3.50	8.64	4.90	5.90	3.60	9.50
Total	100.00	100.00	100.00	100.00	100.00	100.00
Character of the coke	Light spongy.	Pulverulent.	Spongy.	Light spongy.	Light spongy.	Dense.
Color of the ash	Buff-grey.	Grey-buff.	Brownish-grey.	Light grey.	Brown-grey.	Light grey.
Per centage of sulphur	0.836	0.654	1.436	0.836	1.339	0.634

These Perry county coals are remarkably good, containing much less than the average quantity of sulphur, and leaving, generally, but a small amount of ash. With the exception of the cannel, they are semi-bituminous or splint coals, of the same character as the celebrated Block coal of Indiana. The coals of the eastern coal field of Kentucky, as yet measurably unknown and undeveloped, promise to be more valuable in the future than any in the State.

PULASKI COUNTY.

COALS.

No. 1944—"*Coal, from the Cumberland coal banks; mine owned by W. S. Brown and Wm. Owens; two miles south from the Cumberland river; nine miles from Rockcastle Springs; eighteen miles from Somerset. Sub-conglomerate coal. Bed forty inches thick, without a parting. Average sample taken fifty feet from the mouth of the mine. By John H. Talbutt.*"

A pure-looking coal; somewhat tough, with but little fibrous coal and some fine granular pyrites between the laminæ.

No. 1945—"*Coal, from Doolin coal bank; owned by Allen Jones; one mile from Cumberland river; ten miles from Rockcastle Springs. A sub-conglomerate coal. Average sample taken from the head of the drift, seventy-five feet from the mouth. By John H. Talbutt. Bed fifty-one inches thick, containing a good deal of pyrites in some places.*"

A pitch-black splint coal, with but little fibrous coal between the laminæ, but much pyrites.

COMPOSITION OF THESE PULASKI COUNTY COALS, AIR-DRIED.

	No. 1944.	No. 1945.
Specific gravity	1.357	1.357
Hygroscopic moisture	2.40	2.00
Volatile combustible matters	36.76	35.30
Coke	60.84	62.70
Total	100.00	100.00
Total volatile matters	39.16	37.30
Fixed carbon in the coke	50.24	52.94
Ash	10.60	9.76
Total	100.00	100.00
Character of the coke	Spongy.	Light spongy.
Color of the ash	Brownish-lilac-grey.	Dark lilac-grey.
Per centage of sulphur	2.494	3.565

These two samples resemble each other considerably. They are good and profitable coals, although their ash and sulphur per centages somewhat exceed the average.

No. 1946—"CHALYBEATE WATER, *from Rockcastle Springs. From a natural spring on the north side of Rockcastle river, near its margin, and below high-water level. Water said to*

come from a bed of shale; is confined in a box about eighteen inches in diameter, from which it flows in a half-inch stream. Brown-ochreous, ferruginous incrustation on the box. Sample collected by John H. Talbutt."

COMPOSITION OF THIS CHALYBEATE WATER IN 1000. PARTS.

Iron carbonate	0.0145		
Lime carbonate	.0438		Held in solution by carbonic acid.
Magnesia carbonate	.0148	= .0731	
Lime sulphate	.0029		
Magnesia sulphate	.0036		
Soda sulphate	.0531		
Sodium chloride	.0026		
Silica	.0128		
	0.1481		

The water contained 0.0930 per thousand, by weight, of free carbonic acid.

Although containing but a very small proportion of saline matters or of iron, this water may be not the less available in the treatment of many diseases. Indeed, some of the most celebrated mineral waters of the world are nearly pure water. The undoubted curative or restorative effects of such waters depend, not only on their depurative influence, when regularly taken in proper quantity, and the alterative influence of minute proportions of iron compounds or other ingredients present in them, but also on the exercise, change of scene, relaxation of mind, and regular diet and regimen, which are generally to be found at the watering-place. (See Whitley county for other chalybeate springs of this neighborhood.)

ROCKCASTLE COUNTY.

COALS.

No. 1947—"*Coal, from Myzner's and Myers' bank. Livingston. An inter-conglomerate coal. Average sample by A. R. Crandall; taken one hundred and fifty yards in entry No.* 1. *Average thickness of the bed twenty-eight inches.*"

A pure-looking, glossy-black splint coal. But little fibrous coal between the laminæ, and no apparent pyrites.

No. 1948—"*Coal, from same mine. Entry No.* 2. *Average Sample collected by A. R. Crandall.*"

Much like the preceding in appearance.

No. 1849—"*Coal, from Grisham's coal mine, near Livingston. First above the conglomerate. Upper 'brashy coal' bed; average thickness two feet. Average sample by C. J. Norwood.*"

A splint coal. Fibrous coal and much granular pyrites between its thin laminæ.

No. 1950—"*Coal, from same mine. From the lower nine inches of the two feet bed. Local name, 'Block coal.' By C. J. Norwood.*"

A deep-black, glossy coal, iridescent in parts. But little fibrous coal or pyrites apparent.

COMPOSITION OF THESE ROCKCASTLE COALS, AIR-DRIED.

	No. 1947.	No. 1948.	No. 1949.	No. 1950.
Specific gravity	1.318.	1.357	1.327	1.374
Hygroscopic moisture	2.00	2.20	2.20	2.10
Volatile combustible matters	36.66	36.50	35.86	39.50
Coke	61.34	61.30	61.94	58.40
Total	100.00	100.00	100.00	100.00
Total volatile matters	38.66	38.70	38.06	41.60
Fixed carbon in the coke	51.94	51.70	54.94	49.86
Ash	9.40	9.60	7.00	8.54
Total	100.00	100.00	100.00	100.00
Character of the coke	Light spongy.	Light spongy.	Spongy.	Spongy.
Color of the ash	Lilac-grey.	Dark lilac-grey.	Light chocolate.	Purplish-grey.
Per centage of sulphur	2.205	4.802	4.302	2.933

These coals greatly resemble, in general composition, those from near the Cumberland river, described under the head of Pulaski county.

No. 1951—"CLAY, *from Pine Hill coal mines. Rockcastle county. Collected by John H. Talbutt.*"

A light-grey plastic clay, mottled with ferruginous.

This was only examined for its proportion of alkalies. It was found to contain of potash = 3.083 per cent. of the dried clay (at 212°); soda = 0.524 per cent.

It therefore would not probably prove to be a very refractory clay.

No. 1952—"METALLIC IRON. *Brought by Mr. Jones, of Lexington.*"

Said to be from Holley farm, on the dividing ridge between Goose creek and Rockcastle river, head waters of Rockcastle river, near the line of Laurel county. It is similar to a specimen brought to the writer from near Manchester, Clay county, in 1854, by the late Daniel White. Said by both these individuals to be abundant on the surface. It is similar in appearance to some specimens obtained by Mr. C. J. Norwood and others from near Manchester, Clay county, and said to be abundant there.

It presents the appearance of medium fine-grained "mill iron;" is dark-colored; yields to the file, but is quite brittle, extending very little under the hammer. The surface of Mr. Jones' specimen was polished and treated with nitric acid; but while this produced a fine-radiated, Damascus-like appearance, no Widmanstattian figures were produced.

The pieces obtained all seem to be portions of a slab, about one and a half inches thick, the exterior surfaces of which have a coating about one sixteenth of an inch thick of oxide, which looks as though it had either been caused by heat or by a long exposure to the atmosphere.

It was found, on examination, to contain of carbon, about two to three per cent.; silicon, about one per cent.; a doubtful trace of copper, but no nickel.

The per centage of iron was not ascertained, nor was the analysis carried further.

The fact that so many pieces of this iron have been brought to the laboratory, and that so many persons bear testimony to its abundance on the surface in the region in question, is interesting. Is it a meteoric iron? If not, how

came it to be scattered over the ground at such a distance from iron furnaces? Persons in the part of the country where it is found might perhaps throw light on the subject.

WEBSTER COUNTY.

MINERAL WATERS.

No. 1953—"*Water, from the 'Sulphur Spring.' Sebree Springs. Collected by C. J. Norwood.*"

The water, when brought to the laboratory, had deposited a slight black sediment in the bottle, containing some iron sulphide, and had lost its sulphuretted hydrogen. It still contained free carbonic acid gas, the amount of which was not estimated. It gave a slight alkaline reaction. (Analyzed by my son, Alfred M. Peter.)

COMPOSITION IN 1000. PARTS OF THE WATER.

Iron and manganese oxides	0.0007	Held in solution in the recent water by free carbonic acid.
Lime carbonate	.2178	
Magnesia carbonate	.0499	
Lime sulphate	.0617	
Magnesia sulphate	.0570	
Potash sulphate	.0042	
Soda sulphate	.1433	
Sodium chloride	.2760	
Silica	.0176	
Organic matters and loss	.0076	
Total saline matters	0.8358	Dried at 212° F.

Unquestionably a very good saline sulphur water, containing traces of iron and manganese. Part, if not all of the organic matters, may have been derived from the cork.

No. 1954—"*Water, from the 'Chalybeate Spring.' Sebree Springs, &c., &c. Collected by C. J. Norwood. This spring is frequented by people from Henderson and Evansville, &c., and has considerable local reputation.*"

Most of the iron had been deposited in the bottle as a brownish sediment; but this was re-dissolved, analyzed, and calculated into the whole amount in the following report of the analysis. This analysis was also made by Alfred M. Peter.

	COMPOSITION IN 1000. PARTS.	
Iron carbonate	0.0297	Held in solution by carbonic acid.
Manganese carbonate	trace.	
Lime carbonate	.0247	
Magnesia carbonate	.0179	
Lime sulphate	.0218	
Potash sulphate	.0042	
Soda sulphate	.0205	
Sodium chloride	.0026	
Silica	.0010	
Organic matters and loss	.0066	
Total saline matters	0.1290	Dried at 212° F.

The proportion of free carbonic acid in the water was not determined, as doubtless much of it had escaped in transportation. There can be no doubt that it may be made available in the treatment of many maladies, under proper medical advice.

WEBSTER COUNTY SOILS.

No. 1955—"*Virgin Soil. Woods pasture. Farm of Mr. Bowland, near Madisonville. Forest growth: elm, black walnut, red and white oak, &c., &c. Underlying rock; sandstone. Collected by C. W. Beckham.*"

Dried soil of a brownish-buff color; contains no gravel. The silicious residue contained a few small rounded grains of clear quartz.

No. 1956—"*Surface Soil, from a field twelve to fifteen years in cultivation in corn and tobacco; from same farm and near the same locality as the above. Collected by C. W. Beckham.*"

Dried soil of a dark brownish-buff color; contains no gravel. Silicious residue contains a few small rounded quartz grains.

No. 1957—"*Subsoil of the next preceding,*" *&c., &c.*

Dried soil of a buff color; contains no gravel. Silicious residue like the preceding.

COMPOSITION OF THESE WEBSTER COUNTY SOILS, DRIED AT 212° F.

	No. 1955	No. 1956	No. 1957
Organic and volatile matters	4.010	2.975	3.575
Alumina and iron and manganese oxides	4.064	3.997	7.289
Lime carbonate	.145	.220	.145
Magnesia	.178	.160	.124
Phosphoric acid	.071	.118	.061
Sulphuric acid	not est.	not est.	not est.
Potash	.288	.104	.135
Soda	.055	.152	.415
Sand and insoluble silicates	91.350	91.490	88.015
Water, expelled at 380° F.	.400	.225	.500
Loss	....	.559	....
Total	100.561	100.000	100.259
Hygroscopic moisture	1.500	1.375	2.105
Potash in the insoluble silicates	1.461	1.534	1.619
Soda in the insoluble silicates	.759	.698	.912
Character of the soil	Virgin soil.	Cultivated soil.	Subsoil.

These soils are good for sandstone soils, and can be made quite productive by proper management and the judicious use of manures, of which phosphatic fertilizers are indicated. They promise a considerable durability in the considerable proportions of alkalies contained in their insoluble silicates.

WHITLEY COUNTY.

MINERAL WATERS.

No. 1958—"*Chalybeate Water. L. Renfro's. Cumberland Falls. Spring about one hundred yards below the falls, on the north side of the river. From just above the Lower Conglomerate. The sandstone from which it flows is near the level of high water in the river. The water is contained in a small rock basin. It forms an ochreous deposit, and contains some flocculent matter. There are other similar sources in the neighborhood. Collected by John H. Talbutt.*"

No. 1959—"*Chalybeate Water. L. Renfro's. Cumberland Falls. Spring on the south side of the river, just under the falls of Eagle Creek, and about three hundred yards below the falls; above high water. This water deposits an ochreous*

sediment also. It issues from the Conglomerate rock in a wooden spile. Collected by J. H. Talbutt."

COMPOSITION OF THESE CHALYBEATE WATERS, IN 1000. PARTS OF THE WATER.

	No. 1958.	No. 1959.	
Iron and manganese carbonates . .	0.0082	0.0072	Held in solution in the water by carbonic acid.
Lime carbonate	.0476	.0405	
Magnesia carbonate	.0327	.0266	
Silica	.0007	not det'd.	
Lime sulphate.	.0141	.0049	
Magnesia sulphate	.0060	.0060	
Iron and alumina sulphates	.0038	.0053	
Potassium chloride.	not est.	not est.	
Sodium chloride	not est.	.0031	
Silica	.0297	.0176	
Undetermined and loss	.0432	.0088	
Total dry saline contents	0.1860	0.1200	In 1000. parts of the water.

The amount of free carbonic acid in these chalybeate waters was not determined. The judicious use of these waters could no doubt be made quite beneficial in the treatment of many maladies.

No. 1960—*"Bituminous Shale, or impure Coal; from Louis Renfro's land; Cumberland Falls. Bed fifteen inches thick; one hundred and sixty yards below the falls, and one hundred and eighty feet above the river, and about the same distance from it. In massive sandstone; forty feet thick, immediately above. Inter-conglomerate. Collected by John H. Talbutt."*

This shale, air-dried, gave off 2.84 per cent. of *hygroscopic moisture* at 212° F., and 27.16 per cent. of *volatile combustible matters*, leaving 70.00 per cent. of *dense coke*, which contained 26.60 per cent. of *ash*. The *fixed carbon* thus amounted to 43.40 per cent. Its per centage of sulphur was found to be 2.562; so that it may be made available for fuel, &c., in its vicinity, notwithstanding its large proportion of earthy matter.

WHITLEY COUNTY SOILS.

No. 1961—*"Soil; uncultivated; from the bluff opposite Rockcastle Springs. On the Conglomerate. Collected by John H. Talbutt."*

Dried soil of a light umber-grey color. Contains a few small fragments of ferruginous sandstone. The bolting-cloth separated from its silicious residue about one fourth of its bulk of fine, rounded, colorless quartz grains.

No. 1962—"*Virgin Soil; from the top of King's Mountain. Eight hundred feet above the valley. (U. S. Coast Survey Station.) Collected by C. W. Beckham.*"

Dried soil of a brownish-grey color; contains about twenty to thirty per cent. of small shaly ferruginous sandstone fragments. The bolting-cloth separated from its silicious residue a large proportion of fine, rounded grains of hyaline quartz, and greyish, partly decomposed silicates, and a few mica scales.

COMPOSITION OF THESE WHITLEY COUNTY SOILS, DRIED AT 212° F.

	No. 1961.	No. 1962.
Organic and volatile matters	3.075	4.265
Alumina and iron and manganese oxides	3.429	2.695
Lime carbonate	.115	.110
Magnesia	.080	.084
Phosphoric acid	.061	.140
Sulphuric acid	.008	not est.
Potash	.194	.052
Soda	.164	not est.
Sand and insoluble silicates	91.105	91.465
Water, expelled at 380° F.	1.500	.782
Total	99.731	99.593
Hygroscopic moisture	1.200	0.950
Potash in the insoluble silicates	.692	0.989
Soda in the insoluble silicates	.120	.291
Character of the soil	Virgin soil.	Virgin soil.

Better soils than might have been expected from their location.

WOLFE COUNTY.

COALS.

No. 1963—"*Coal, from C. M. Hanks' bank. Compton. Bed twenty-eight inches thick; without parting. Sample by A. R. Crandall.*"

A pure-looking, pitch-black coal. Has but little fibrous coal. Some shining pyritous scales in the seams.

No. 1964—"*Cannel Coal, or Bituminous Shale. James F. Ely's. Gilmore Creek. Sample by P. N. Moore.*" Hand specimen.

A dull-looking cannel coal, breaking with difficulty. No appearance of fibrous coal or pyrites. Small glimmering micaceous scales abundant in it.

No. 1965—"*Cannel Coal. John W. Faukner's. Stillwater Creek. Collected by P. N. Moore.*" Not an average sample.

A dull-black, pure-looking coal, with a large conchoidal fracture.

No. 1966—"*Coal, from Hobb's bank, on Benjamin Baker's land; four and a half miles from Compton. Collected by P. N. Moore.*"

A pure-looking splint coal. A little fibrous coal and fine granular pyrites between some of its laminæ. One piece contained some particles of light reddish-brown *resin.*

COMPOSITION OF THESE WOLFE COUNTY COALS, AIR-DRIED.

	No. 1963.	No. 1964.	No. 1965.	No. 1966.
Specific gravity	1.336	1.434	1.383	1.294
Hygroscopic moisture	3.74	1.30	1.16	3.50
Volatile combustible matters	35.52	41.40	44.58	35.20
Coke	60.74	57.30	54.26	61.30
Total	100.00	100.00	100.00	100.00
Total volatile matters	39.26	42.70	45.74	38.70
Fixed carbon in the coke	52.64	28.20	32.76	56.70
Ash	8.10	29.10	21.50	4.60
Total	100.00	100.00	100.00	100.00
Character of the coke	Spongy.	Pulverulent.	Pulverulent.	Spongy.
Color of the ash	Lilac-grey.	Nearly white.	Light lilac-grey.	Lilac-grey.
Per centage of sulphur	2.466	0.846	0.530	1.189

The so-called cannel coals contain so much earthy matter that they might (one or both) be properly called bituminous shales. They are remarkable, however, for the large proportion of volatile combustible matters they yield; and hence may be made available, if the petroleum production fails, in the manufacture of the coal oil and other hydrocarbons, &c., which are now so extensively used. They will make quite good fuel, notwithstanding their large ashy residue. Coal No. 1966 is exceptionally pure and good, and No. 1963 is also quite a good coal.

TABLE I. SOILS, SUBSOILS, &c., DRIED AT 212° F.

Number in Report.	County.	Organic and volatile matters	Alumina and iron and manganese oxides	Lime carbonate.	Magnesia	Phosphoric acid	Sulphuric acid.	Potash	Soda.	Sand and insoluble silicates	Water expelled at 380° F.	Water expelled at 212° F.	Potash in the insoluble silicates.	Soda in the insoluble silicates.	Remarks.
1677	Bell	4.700	4 817	0.190	0.338	0 093	not est	0.164	0.115	89 390	0.600	1 825	2 568	0 389	J Turner's, val of Big Yel. Cr.; vir. s.
1678	Bell	5 575	4.015	190	.067	.220	not est	160	217	88 875	775	2 550	735	018	J Turner's, old field soil.
1679	Bell	2 600	1 710	.115	.045	125	not est	056	.006	93 940	900	1.350	850	082	J Turner's subsoil
1680	Bell	5 725	4 339	065	.050	096	not est	.068	035	89.390	650	1.800	568	119	J Turner's, virgin soil (foot-hills).
1681	Bell	2 750	4 137	.065	.042	.073	not est	106	032	92 090	.885	875	713	137	J Turner's, subsoil
1682	Bell	5 050	3 557	.265	131	093	not est	212		90 215	750	1 875	347	167	Cultivated field soil.
1683	Bell	1 800	2 474	115	.060	061	not est	085	014	95 115	.750	850	501	216	Cultivated subsoil.
1684	Bell	11 565	4 015	145	098	125	not est	139	074	84 040	035	3 700	583	.090	Virgin soil top of Brison Mt.
1685	Bell	5 750	4 662	.145	.079	108	not est	131	039	88 540	.900	2 275	717	150	Subsoil, top of Brison Mt.
1686	Bell	4 050	4 197	.095	.068	093	not est	128	not est	90 440	.750	1 475	1 387	213	Virgin soil, Yellow Creek Valley.
1687	Bell	3 925	8 846	.280	.052	124	not est	139	.085	83 140	1 100	2 450	2 507	.344	Old field, Big Creek Valley.
1688	Bell	4 850	8 120	095	088	093	not est	.191	117	86 040	750	1.875	2 275	251	Old field, subsoil
1689	Bell	5 525	7.339	095	.088	061	not est	143	.063	85 140	1 200	2 225	2 362	.273	Old field, Big Yellow Creek Valley.
1690	Bell	4 725	7 013	095	.088	.077	not est	.243	. .	87 125	1 000	1.900	2 351	.	Old field, subsoil Big. Yel. Cr. Valley.
1691	Bell	3 500	2 913	290	070	093	.007	.158	050	92 090	1 100	1 150	496	.169	Old field, foot of Cumberland range.
1692	Bell	2 450	2 815	275	.044	.125	003	.203	013	92 040	1 050	1 175	674	186	Old field, subsoil, Ft of Cumb'd range.
1693	Bell	4.125	5 990	.225	.080	.125	007	.109	177	87 590	1 450	1.500	1 831	561	Cultivated field, foot-hills
1694	Bell	4 025	6 997	.225	.081	093	.007	.368	. .	86 815	1 250	1.515	1 964	348	Cultivated field, subsoil, foot-hills.
1695	Bell	7 175	9 626	265	155	189	007	.429	190	80 040	2 075	2.500	2 519	303	Old field, Big Yellow Creek Valley
1696	Bell	5 675	12.816	115	.322	294	013	.443	. . . .	78 240	2 025	2 525	2 640	464	Old field, subsoil, Big Yel Cr. Valley.
1723	Christian	4 200	4 810	065	.155	.125	not est	.335	. . .	89 940	.475	1 725	925	434	Virgin woodland soil (sandstone).
1724	Christian	4 360	6.467	125	.151	068	not est.	176	261	88 720	.500	1.740	.980	.479	Cultivated soil (for 15 years).
1725	Christian	3.135	9 310	.120	130	.150	not est	.083	.116	86 290	375	1 900	1 131	561	Subsoil of preceding.
1726	Christian	3 300	3 922	095	115	038	not est	121	.172	91.850	250	925	1.462	.569	Virgin soil.
1727	Christian	4.330	6 402	.220	.106	108	not est	.247	.153	87 925	.325	1 500	1 457	875	Old field soil
1728	Christian	4 065	12 155	160	164	.080	not est	.637	084	81 890	.450	2.800	1.367	1 044	Subsoil
1729	Christian	5 165	5 540	270	178	070	not est,	.385	. . . .	88 615	.595	1.710	1 669	.478	Virgin soil (compact limestone).
1730	Christian	4 065	4 618	270	124	.042	not est	.256	. . . .	88.915	445	1 590	1 642	.605	Old field soil
1731	Christian	3 600	11 193	295	.142	093	not est,	.457	. . . .	83 645	400	3.000	1.516	.662	Subsoil
1732	Christian	2 625	4 036	.130	.097	124	not est.	.221	.225	92 625	450	1 050	1.421	.575	Virgin soil (sandstone).
1733	Christian	2 925	5 992	.170	.153	.093	not est	125	. . . .	89 755	.550	1 365	1.166	.420	Old field soil (sandstone).
1734	Christian	2 775	9 052	.070	156	108	not est.	.174	. . . .	86 575	.600	2 165	1.368	461	Subsoil (sandstone).
1735	Christian	4 675	4 127	190	.167	.108	not est	.260	. . . .	89.765	725	1.600	1.344	.543	Virgin soil (limestone).
1736	Christian	3 115	5 884	270	151	086	not est,	.210	. . .	89 815	.550	1 400	1.863	325	Old field soil (limestone).
1737	Christain	3.500	12 727	295	.232	.108	not est.	.707	. . .	81.890	.750	3.235	. . . .	. . . .	Subsoil (limestone).
1750	Daviess	5 475	6 174	.120	016	141	not est	134	.301	86.605	.975	1.775	.855	.582	Virgin soil, hill top.
1751	Daviess	3 150	7 065	.845	.034	.125	not est.	.053	. . . .	88.390	.925	1.515	1.122	.709	Old field, hill top.
1752	Daviess	2.715	10 654	.095	.021	.061	not est	.244	. . . .	85 415	.910	1.565	1.386	.680	Subsoil, hill top.
1753	Daviess	5 875	5 349	.220	.044	.086	not est.	.407	. . . .	86.590	1.450	1.700	.975	.403	Virgin soil, upland.
1754	Daviess	4 350	3.500	.085	.133	.083	not est.	.265	. . . .	90 890	.600	.875	1.396	.729	Old field, upland.
1755	Daviess	3.175	12.958	.075	.080	.108	not est.	.475	.075	81.300	1.275	3.500	1.457	.639	Subsoil; upland.

1779	Fayette	4.676	9.570	0.230	0.140	0.444	not est.	0.287	not est.	82.860	1.824	2.165	1.274	0.211	Woodland pasture (blue grass) soil.
1780	Fayette	3.085	10.445*	.220	.140	.540	not est.	.343	.192	83.260	1.234	1.965	1.314	.583	Subsoil to same.
1781	Fayette	7.800	12.286	1.145	.394	.364	not est.	.735	.084	76.690	1.300	2.975	.718	.200	Virgin open pasture; blue grass soil.
1782	Fayette	4.410	14.427	.545	.340	.358	not est.	.402	.301	77.440	.925	3.135	.910	.212	Subsoil to same.
1783	Fayette	4.400	19.921	.130	.376	.364	not est.	.755	. . . .	72.540	1.200	3.525	.644	.167	Under clay of same.
1809	Greenup. . . .	5.590	12.357	.045	.366	.083	.003	.433	.023	79.500	1.250	1.900	2.301	.509	Vir. soil; woods; hill top; Wh. Oak Cr.
1810	Greenup. . . .	5.600	15.693	.070	.375	.147	trace.	.474	.305	76.060	.950	2.235	2.829	.368	Subsoil to same.
1811	Greenup. . . .	4.375	7.060	.270	.083	.115	.027	.098	.068	86.890	1.100	1.150	1.220	.520	Cultivated field; Valley Wh. Oak Cr.
1812	Greenup. . . .	3.790	6.656	.745	.067	.109	.033	.193	.163	87.665	.910	1.000	.817	.380	Subsoil to same.
1837	Hopkins . . .	3.950	5.845	.125	.088	.080	not est.	.193	. . . .	88.015	1.375	1.750	1.686	.425	Virgin soil; woods; sandstone.
1838	Hopkins . . .	3.900	5.936	.235	.137	.099	not est.	.086	.145	88.115	1.150	1.600	1.528	.371	Cultivated field; sandstone.
1839	Hopkins . . .	3.100	10.321	.115	.035	.064	not est.	.354	. . . .	84.665	1.050	2.600	1.149	.621	Subsoil of same.
1840	Hopkins . . .	5.895	5.649	.385	.142	.061	not est.	.348	.103	86.590	.625	1.580	1.336	.604	Vir. soil; w'ds; Morton's Gap; sandst'e.
1841	Hopkins . . .	4.000	6.153	.245	.092	.032	not est.	.300	.213	89.195	.420	1.225	1.272	.588	Old fi'd soil; Morton's Gap, sandstone.
1842	Hopkins . . .	3.080	7.224	.245	.095	.061	not est.	.498	.235	88.415	.550	1.335	1.236	.621	Subsoil of same.
1843	Hopkins . . .	7.125	6.322	.395	.162	.163	not est.	.325	.020	85.200	.875	1.775	1.152	.493	Vir. soil, near Nortonsville; sandstone.
1844	Hopkins . . .	3.185	5.155	.120	.124	.080	not est.	.292	.186	91.455	.430	.730	1.163	.388	Old field, near Nortonsville; sandstone.
1845	Hopkins . . .	3.815	10.090	.145	.269	.045	not est.	.518	.251	85.160	.685	2.160	1.247	.488	Subsoil of same.
1852*a*	Knox	3.453	5.456	.100	.158	.179	not est.	.125	.576	89.115	.741	.815	1.648	.130	Vir. soil; foot of Pt. Hill K'bs; s'dst'e.
1852*b*	Knox	4.374	8.781	.120	.158	.104	not est.	.261	not est.	85.165	.621	.900	1.648	.446	Old fi'd soil; f't of Pt. Hill K'bs; s'dst'e.
1852*c*	Knox	5.658	7.825	.095	.158	.185	not est.	.467	not est.	84.765	.909	1.025	2.320	.546	Vir. soil; top of Paint Hill Knobs.
1852*d*	Knox	2.800	2.835	.045	.016	.055	not est.	.112	.021	93.790	.525	.950	.399	.235	Virgin soil; Cumberland R. Valley.
1852*e*	Knox	2.765	1.904	.130	.029	.061	not est.	.094	not est.	94.530	.535	.435	.409	.150	Old fi'd soil, same locality as next above.
1852*f*	Knox	1.750	3.644	.045	.025	.031	not est.	.130	not est.	93.215	1.675	.435	.718	.119	Subsoil of same.
1853	Laurel	6.110	5.298	.110	.011	.077	not est.	.229	.149	87.330	1.100	.865	.843	.171	Virgin soil (sandstone).
1854	Laurel	3.625	4.882	.130	.025	.083	not est.	.312	.268	90.230	.725	.550	.661	.211	Old field soil, same locality.
1855	Laurel	2.450	5.719	.145	.016	.071	not est.	.110	.228	90.780	.400	.575	.892	.214	Subsoil of the next above.
1856	Laurel	5.990	7.339	.070	.124	.096	not est.	.217	. . . .	84.415	1.075	1.535	.939	.400	Virgin soil near London (sandstone).
1857	Laurel	3.475	7.361	.120	.053	.099	not est.	.074	. . . .	87.740	.675	.800	.862	.623	Old field soil (same locality).
1858	Laurel	3.740	9.385	.110	.075	.100	not est.	.447	. . . .	85.365	.725	1.425	.975	.575	Subsoil of next preceding.
1870	Lewis	3.325	10.965	.125	.266	.125	trace.	.501	.116	83.465	1.025	3.000	1.843	1.036	From Ohio Bottom.
1871	Lewis	2.665	8.995	trace.	.092	.125	.015	.387	.128	86.365	.685	2.225	1.233	.868	Subsoil of same.
1872	Lewis	4.425	9.545	.180	.208	.205	.050	.462	.134	83.100	1.725	2.335	1.138	.954	Old field soil; back of Ohio Bottom.
1903*a*	Muhlenburg . .	3.325	4.137	.345	.176	.189	trace.	.145	not est.	90.215	1.222	1.800	1.339	.716	Virgin soil (A. Stroud's farm).
1903*b*	Muhlenburg . .	1.052	3.548	.006	.167	.102	trace.	.167	not est.	94.340	1.050	.775	1.091	.564	Subsoil of same (A. Stroud's farm).
1903*c*	Muhlenburg . .	1.242	3.749	.145	.122	.121	trace.	.255	.477	93.140	1.242	.965	1.113	.474	Old field soil of same (sandy shale).
1955	Webster. . . .	4.010	4.064	.145	.178	.071	not est.	.288	.055	91.350	.400	1.500	1.461	.759	Vir. soil; woods pasture near Madis'v'e.
1956	Webster. . . .	2.975	3.997	.220	.160	.118	not est.	.104	.152	91.490	.225	1.375	1.534	.698	Cultivated field (same locality).
1957	Webster. . . .	3.575	7.289	.145	.124	.061	not est.	.135	.415	88.015	.500	2.105	1.619	.912	Subsoil of same.
1961	Whitley	3.075	3.429	.115	.080	.061	.008	.194	.164	91.165	1.500	1.200	.692	.120	Virgin soil (on bluff); conglomerate.
1962	Whitley	4.265	2.695	.110	.084	.140	not est.	.052	. . . .	91.465	.782	.950	.989	.291	Virgin soil; top of King's Mountain.

*Containing: of alumina 6.093, iron peroxide 4.330, and manganese oxide 0.021 per cent.

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TABLE II. COALS, AIR-DRIED.

Number in Report.	County.	Specific gravity	Hygroscopic moisture.	Volatile combustible matters.	Coke.	Total volatile matters.	Fixed carbon in the coke.	Ash.	Character of the coke	Color of the ash	Per centage of sulphur.	Remarks.
1667	Bell	1 276	1 90	37.50	60.60	39.40	57 90	2 70	Light spongy	Light-brown	1 519	Abram Lock's coal, Straight Creek.
1668	Bell	1.362	1.00	43.60	55.40	44 60	47.80	7 60	Dense spongy	Buff grey	590	Cannel coal; Col. Eves', Stony Creek.
1669	Bell	1 346	1 80	35 50	62 70	37 30	52 20	10 50	Light spongy	Very light grey	956	Hignite coal, Branch of Yellow Creek, upper bed.
1670	Bell	1 290	2 04	36 64	61 32	38 68	58 02	3 30	Light spongy	Light lilac-grey	736	Hignite coal, Branch of Yellow Creek, middle bed.
1671	Bell	1 277	2.96	35 28	61.76	38 24	59 40	2 36	Light spongy	Brownish-grey	420	Hignite coal, Branch of Yellow Creek, lower bed.
1672	Bell	1 360	1 02	37 70	61 29	38 78	48 22	13 00	Light spongy	Lilac-grey	1 670	From Little Clear Creek
1673	Bell	1 325	1.76	38 90	59.34	40 66	52 54	6 80	Light spongy	Lilac grey	2 027	From Little Clear Creek
1674	Bell	1 344	1 26	33 96	64.78	35 22	55 42	9 36	Light spongy	Light lilac-grey	2 672	From Fork Ridge, Stony Creek.
1675	Bell	1 282	1 36	35 80	62 84	37 16	59 54	3 30	Light spongy	Buff grey	.975	Jas Barnett's, Clear Fork
1676	Bell	not est	1 50	37 94	60 50	39 44	58 40	2 16	Light spongy	Brownish-buff	1 038	Jas Barnett's, Clear Fork, market sample.
1702	Breathitt	1 405	3 30	31 44	65 26	34 74	49 76	12 50	Dense friable	Pinkish grey	991	Roberts' bank, Troublesome Creek, bituminous part.
1703	Breathitt	1 282	3.40	43 40	53 20	46 80	46 96	6 24	Friable	Light buff grey	630	Roberts' bank, Troublesome Creek, cannel part
1704	Breathitt	1 290	2.20	39 20	58 60	41 40	51 14	7 46	Spongy	Lilac-grey	2 525	Roberts' bank, Troublesome Creek, middle part.
1705	Breathitt	1 265	1.30	47 00	51 70	48 30	44 40	7 30	Dense	Brownish-grey	1 574	Haddock's cannel coal, Troublesome Creek.
1706	Breathitt	1 360	1.60	43 20	55 20	44 80	33 80	21 40	Pulverulent	Light-buff	2 549	Johnson's cannel coal, Frozen Creek
1707	Breathitt	1 180	1 20	59 80	40 00	60 00	35 30	4 70	Dense	Light grey buff.	not est	Johnson's cannel coal, Frozen Creek.
1708	Breathitt	1 300	2 50	41 10	56 40	43 60	49 22	7 18	Light spongy	Dark lilac	818	Johnson's canne. coal, Frozen Creek.
1709	Breathitt	1 328	2 10	43 10	54 80	45 20	43 36	11 44	Spongy	Light grey	4 609	Cannel coal, A Little's, Quicksand Creek.
1710	Breathitt	1 398	2 78	35 52	61.70	38 30	44 94	16.76	Dense spongy	Light lilac-grey	1 423	Jackson Wells' coal, Troublesome Creek.
1711	Breathitt	1 280	.94	52 36	46 68	53 32	35 54	11 14	Dense	Light lilac-grey	1 403	Cannel coal, George's Creek
1712	Breathitt	1 290	4 90	35 30	59 80	40 20	55 50	4 30	Spongy	Light grey	3 153	Simon Holland's coal
1713	Breathitt	1 290	2.76	36 26	60 50	39 44	56 50	4 03	Light spongy	Light yellowish-grey	805	Wolf Creek bank coal
1714	Breathitt	1.297	3 50	33 50	62 88	37 12	58 38	4.50	Light spongy	Light lilac-grey	1 381	Wm Spencer's coal, North Fork of Kentucky River.
1719	Christian	1 307	4.60	31 94	63 46	36 54	54 36	9 10	Dense	Light lilac-grey	1 469	Coal I, Coalton banks
1720	Christian	1.332	5 10	32 50	62 40	37 60	51 70	6.70	Very dense	Light lilac-grey	1 277	Coal L, two miles south of Petersburg.
1721	Christian	1.398	3 70	32 50	63.74	36 26	52 04	13 70	Light spongy	Greyish-brown	3 716	Coal J, at Petersburg Station, St. L. & S. E. R. R.
1742	Clinton	1 329	1 50	37 74	62.70	39 30	50 20	10.50	Light spongy	Light lilac-grey	2 911	Conglomerate main coal, Cumberland mines.
1757	Daviess	1.323	6 20	36 20	57 60	42 40	50 90	6 70	Light spongy	Lilac-grey	1 519	Coal 2, Montgomery's mine
1758	Daviess	1 340	4 10	38 50	57.40	42.60	51 00	6 40	Spongy	Lilac grey	1 538	Coal D, Dutch mine.
1759	Daviess	1 318	5 80	35 06	59.14	40 86	50 40	8 74	Light spongy	Light lilac-grey	3 985	Coal D, Ton Harbor mines.
1760	Daviess	1.337	5.22	34 72	60.16	39.84	51 44	8 72	Light spongy	Light lilac-grey	3 513	Coal D, Dean's mine
1761	Daviess	1.385	6 20	41 40	51 90	48 10	47 40	4 50	Light spongy	Grey-lilac	3 743	Coal from Duncan's bank, near Knottsville.
1784	Floyd	1 289	3.20	38 80	58.00	42.00	55.04	2.96	Light spongy	Light chocolate	2 32	Coal from Snipe's bank, Abbott's Creek.
1785	Floyd	1.274	2.50	40.80	56 70	43 30	53 40	3.24	Light spongy	Light lilac-grey	1 895	Coal from Harris' bank, Muddy Creek
1786	Floyd	1 307	2 50	38 56	58.94	41 06	53 44	5 50	Spongy	Light lilac-grey	2 915	Coal from Hatcher's bank, Abbott's Creek.
1787	Grayson	1.343	6 50	30 04	63.46	36.54	55 54	7 92	Quite dense	Light lilac-grey	1 972	Coal from South or Allen bank, Falls of Rough Creek.
1795	Greenup	1.347	4 24	34 76	61.00	39 00	48 70	12 30	Spongy	Light lilac-grey	1 601	Turkey Lick coal.
1796	Greenup	1.331	4 00	37 70	58.30	41 70	51 00	6 70	Dense spongy	Lilac-grey	2 645	Coal 3, Turkey Lick, Pennsylvania Furnace.
1797	Greenup	1.280	4.36	30 68	58.76	41.24	52 40	6 36	Light spongy	Very light lilac-grey	.682	Turkey Lick coal mines, main entry
1798	Greenup	1.338	4.60	34 80	60.60	39.40	51.00	9.60	Dense spongy	Very light lilac-grey	.667	Turkey Lick coal, old entry.

1799	Greensp.	1	384	4	221	30	104	65	68	34	321	53	681	12	001	Friable	Light lilac-grey		985	Raccoon Furnace coal.
1800	Greensp.	not	est.		19	20		80	801	19	2	75	10	5	701		Nearly white		666	Coke from Coal 3, Turkey Lick coal, Hunnewell Furn.
1813	Hancock	1	223	1	301	59	601	[illegible]	100	60	901	27	001	22	10	Dense; friable	Light grey brown	1	890	Cannel coal, Cloverport Oil Company coal, entry No. 2a.
1814	Hancock	1	357	5	82	36	[illegible]	[illegible]	[illegible]	41	4	47	60	11	001	Dense	Lilac-grey	4	038	Hancock Coal Company mines
1815	Hancock	1	353	5	401	34	[illegible]	[illegible]	[illegible]	40	201	49	30	1	90	Spongy	Light brownish-grey	2	398	Milton Lawson's bank, Lead Creek
1816	Hancock	1	323	3	501	43	4	[illegible]	[illegible]	46	30	45	50	7	54	Light spongy	Purplish chocolate	4	155	Robert Estes' bank, back of Lewisport.
1817	Hancock	1	289	4	801	38	[illegible]	[illegible]	[illegible]	43	701	50	201	[illegible]	24	Light spongy	Light brownish-grey	2	318	Jas Mason's bank, between Hawesville and Lewisport.
1818	Hancock	1	401	4	50	37	[illegible]	[illegible]	[illegible]	42	1	47	46	1	44	Dense spongy	Light chocolate	7	801	Colbert's bank, near Lewisport
1819	Hancock	1	337	[illegible]	20	38	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	45	[illegible]	48	501	Dense spongy	Light lilac grey	2	186	Bergenroth's bank, near Old Reverdy mines.
1820	Hancock	1	308	7	40	33	201	59	401	40	60	[illegible]	20	4	20	Dense spongy	Light grey	1	368	John C Schafer's bank, Blackford Creek.
1821	Hancock	1	292	5	201	41	[illegible]	53	701	40	30	46	60	7	10	Light spongy	Light lilac grey	3	331	Breidenbach's bank, Lead Creek
1822	Hancock	1	268	3	30	39		51	701	42	3	50	501	7	201	Light spongy	Brownish grey	3	373	Davidson bank, near Hawesville
1823	Hancock	1	292	6	001	37	80	[illegible]	[illegible]	43	801	48	70	7	50	Spongy	Greyish lilac	3	180	R S Lanum's bank, near Hawesville.
1824	Harlan	1	510	1	401	34	601	[illegible]	[illegible]	[illegible]	[illegible]	99	401	24	701	Dense	Chocolate	1	271	Cannel coal or bituminous shale, Martin's Fork.
1825	Harlan	1	289	1	701	35	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	59	60	3	10	Very light spongy	Light buff		750	J C Howard's bank, Clover Fork, Cumberland river.
1826	Harlan	1	356	5	201	31	70	[illegible]	[illegible]	36	401	[illegible]	[illegible]	3	40	Pulverulent	Light buff		618	Martin's Fork, Skidmore Creek.
1829	Hopkins	1	351	5	001	35	[illegible]	51	74	40	26	40	20	10	50	Light spongy	Brownish grey	3	015	Coal D, Diamond coal mines
1830	Hopkins	1	337	4	301	37	801	58	001	41	90	50	50	7	50	Light spongy	Dark brownish-grey	2	802	Coal D, St Bernard coal mines.
1831	Hopkins	1	366	3	801	36	30	0	001	89	90	49	001	11	10	Light spongy	Lilac grey	5	955	Coal B, Fleming coal mine, bottom portion.
1832	Hopkins	1	890	2	701	40	70	56	50	43	40	51	60	4	90	Light spongy	Light lilac grey	1	50	Coal B, Fleming coal mine, top portion
1833	Hopkins	1	373	3	281	39	32	51	401	42	601	49	90	7	801	Light spongy	Lilac grey	4	710	Coal B, Hecla coal mines, average sample.
1834	Hopkins	1	396	3	821	36	381	50	801	40	201	51	501	8	701	Light spongy	Lilac grey	3	619	Coal B, Hecla coal mines, lower bench
1835	Hopkins	1	396	3	201	38	201	58	501	41	50	48	10	10	001	Light spongy	Lilac grey	3	349	Coal B, St Bernard coal mines, lower drift.
1836	Hopkins	1	331	2	321	37	081	60	001	40	00	51	001	9	001	Light spongy	Lilac grey	3	016	Coal D, Hecla coal mines, average sample.
1846	Jackson	1	338	2	001	41	201	57	001	43	00	43	201	13	401	Spongy	Very light buff grey	1	490	Cannel coal, Tom Coyle's bank, 100 feet above Congo.
1847	Jackson	1	321	2	001	43	[illegible]	59	30	43	[illegible]	45	50	8	701	Dense	Grey-chocolate	3	304	Cannel coal, T J Ballard's bank, Horse Lick.
1849	Johnson	1	291	2	701	[illegible]	[illegible]	50	801	40	20	51	201	8	801	Dense	Light [illegible] grey		958	Cannel coal, Lick Branch, White House Creek.
1850	Johnson	1	894	3	101	38	60	50	301	41	7	53	50	4	501	Light spongy	Light [illegible]	1	75	Rice's coal, head of Jenny's Creek.
1851	Johnson	1	880	2	601			59	30	40	7	[illegible]	[illegible]	3	001	Spongy	Light grey	2	291	Coal from Wheeler's bank, near Paintsville
1859	Lawrence	1	317	5	201	14	[illegible]	[illegible]	[illegible]	17	401	55	501	7	10	Dense	Light brownish grey	11	901	Coal 3, Peach Orchard, Miller's Branch opening.
1860	Lawrence	0	0	3	24	40	5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	5	24	Dense	Light lilac grey	1	134	Coal 3, Peach Or'd, Miller's Br'h opening (weathered).
1861	Lawrence	1	245	[illegible]	84	43	[illegible]	[illegible]	[illegible]	[illegible]	00	[illegible]	[illegible]	3	701	Dense	Buff	1	076	Cannel coal, Little Laurel Creek
1865	Lee	1	331	2	30	43	10	57	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Light spongy	Lilac-grey	2	350	From Dan'l Scott's bank, near Proctor.
1866	Lee	1	334	2	101	38	201	61	801	40	201	51	84	8	201	Spongy	Lilac-grey	3	941	Same locality as above, another entry
1867	Lee	1	307	4	001	35	301	[illegible]	[illegible]	49	501	55	5	5	10	Light spongy	Light lilac grey	1	41	Pryse's coal, Lower Stufflebean Creek.
1868	Lee	1	317	3	101	36	601	[illegible]	[illegible]	39	74	54	[illegible]	3	30	Dense spongy	Light brown grey	1	34	From Phillip's bank, Mirey Creek.
1869	Lee	1	330	1	401	32	701	63	401	36	101	57	601	6	301	Spongy	Light lilac grey	1	368	From R B Jameson's bank, Mike's Branch.
1877	Madison	1	281	2	661	33	[illegible]	63	661	36	34	56	201	7	901	Dense spongy	Nearly white		824	Cox's coal bank, top of Big Hill
1878	Madison	1	282	1	901	45	701	52	101	47	661	44	861	7	481	Dense	Nearly white	2	888	Moran's mine, top of Big Hill
1878a	Magoffin	1	273	1	801	45	601	52	001	47	401	43	401	9	201	Dense spongy	Buff-grey		688	Salyersville coal (half cannel, lower portion.
1879	Magoffin	1	292	2	701	38	041	59	261	40	741	51	621	7	641	Light spongy	Very light brownish grey	1	470	Salyersville coal (half cannel), upper portion.
1880	Magoffin	1	309	4	341	37	361	58	101	42	701	53	141	5	161	Spongy	Light purplish grey	1	117	Amos Davis coal, on Licking river.
1881	Magoffin	1	270	3	701	36	041	59	601	40	341	54	601	4	981	Ligh. spongy	Light buff grey		144	Sacye Bank coal, near Mouth of Johnson's Creek.
1882	Magoffin	1	250	0	301	51	401	45	501	54	201	37	561	8	241	Very dense	Brownish grey	1	415	Colvin's cannel coal
1883	Martin	1	351	2	761	33	[illegible]	[illegible]	4	35	701	55	261	2	181	Light spongy	Brownish grey	2	51	Coal 1, Mouth of Collins' Creek, Warfield
1884	Martin	1	368	2	501	33	[illegible]	[illegible]	[illegible]	36	201	52	021	12	181	Light spongy	Light lilac grey		754	Coal, Warfield, Tug Fork
1885	Martin	1	350	2	241	31	001	[illegible]	[illegible]	35	321	52	701	12	401	Dense	Very light lilac grey		804	Warfield splint coal, above main coal.
1886	Martin	1	377	3	101	31	581	[illegible]	[illegible]	35	441	52	261	12	501	Dense	Very light lilac-grey		871	Eight-feet coal, head of Laurel Fork of Nat's Creek.
1887	Martin	1	304	2	001	35	121	[illegible]	[illegible]	37	121	54	821	6	061	Dense	Lilac-grey		98	Coal 1, Warfield
1888	McLean	not	est.	1	601	46	401	2	201	38	001	31	801	3	701	Friable	Brownish lilac grey	not	est.	Bituminous shale, near Wrightsburg.
1889	McLean	1	241	1	361	38	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	59	161	2	821	Light spongy	Buff grey	1	124	Coal, near Wrightsburg.
1890	Morgan	1	231	1	061	49	[illegible]	[illegible]	48	101	52	701	1	201	5	101	Spongy	Light buff grey		955	Pierat's cannel coal
1891	Morgan	1	331	2	301	41	[illegible]	56	101	43	901	44	701	11	401	Very dense spongy	Grey-buff	1	271	Cannel coal, Maynhier's bank, Elk Fork, Licking river.

TABLE II. COALS, AIR-DRIED—(Continued).

Number in Report.	County.	Specific gravity	Hygroscopic moisture	Volatile combustible matters	Coke.	Total volatile matters	Fixed carbon in the coke	Ash	Character of the coke	Color of the ash.	Per centage of sulphur	Remarks
1892	Morgan	1.353	4.26	35 24	35 24	39 50	50 10	10 40	Dense spongy	Nearly white	1 011	Six-foot coal, near West Liberty
1896a	Menifee	1.300	5 00	39 06	55 94	44.06	53 18	2 76	Spongy	Brownish lilac-grey	1 199	Price and Fitch's bank, top of the mountain.
1896b	Menifee	1 300	5 00	32 40	62 60	37 40	58 40	4 20	Dense	Light yellowish grey	.614	Adams' bank, Old Slate Branch, near Frenchburg.
1896c	Menifee	1 318	2 70	38 22	59.08	40 92	54 80	4 20	Spongy	Lilac-grey	1 615	Old State Road Branch
1898	Muhlenburg	1 280	4 60	42 60	52.80	42 70	50 00	7 74	Spongy	Light grey	1 601	Coal B, Louisville and Stroud City mines (top of bed).
1899	Muhlenburg	1 309	3 36	37 90	58 74	41 26	52 74	6 00	Light spongy	Light lilac-grey	2.686	Coal B, Memphis Coal Company's mine
1900	Muhlenburg	1 313	5 40	35 90	58 70	41 30	53 60	5 10	Light spongy	Light lilac-grey	2.219	Coal B, Louisville and Stroud City mine.
1901	Muhlenburg	1 235	5 40	34.20	60 40	39 60	54 20	6 20	Light spongy	Bright lilac grey	3.136	Coal B, St. Louis mines, Owensboro Junction.
1902	Muhlenburg	1.309	4 60	37 60	57 80	42 20	52 64	5 16	Light spongy	Dark brownish grey	2 372	Coal B, St Louis mines "Gas coal."
1903	Muhlenburg	1 332	3 80	36.20	60 00	40.00	51 80	8 20	Light spongy	Lilac grey	3.194	Coal B Rothrock's mine (upper bench).
1904	Ohio	1 318	3 80	36.66	59 54	40 46	52 00	7 54	Spongy	Light lilac-grey	1 944	Coal D, McHenry coal mine (without sulphur band).
1905	Ohio	1 331	2 70	35 24	62 06	37 94	53 62	8 44	Light spongy	Lilac-grey	3 785	Coal D, McHenry coal mine (with sulphur band).
1906	Ohio	1 310	4 40	38 20	57 40	42 60	49 44	7 46	Light spongy	Light lilac-grey	2.240	Coal D, Render mine From out coal pile.
1907	Ohio	1.336	4 10	34 30	61 54	38 46	51 24	10 30	Light spongy	Lilac-grey	3 263	Coal D, Render mine From the slack pile.
1908	Ohio	1.295	5 00	36 74	58 26	41 74	55 66	2 60	Light spongy	Light brown	1.605	From Ch W Stephens' bank, Rough Creek.
1909	Ohio	1.297	5 90	33 80	60 30	39 70	56 90	3 40	Light spongy	Buff	1 038	From G B Hocker's bank, Rough Creek.
1910	Ohio	1 351	5 54	35 66	58 80	41 20	55 20	2 60	Light spongy	Light-buff	983	From same locality as last
1911	Ohio	1.382	5 10	30 70	64 20	35 80	54 24	9 96	Spongy	Light brtish lilac grey	2.164	From Marion Sandifer's bank, Big Muddy Creek.
1912	Ohio	1 386	4 80	33 70	61 50	38 50	52.26	9.24	Spongy	Brownish lilac grey	3 364	From L M Patterson's mine, Point Pleasant.
1913	Ohio	1 345	1 50	36 30	60 20	39 80	50 92	9 28	Light spongy	Brownish lilac grey	3 594	Coal D, Williams' coal bank, Ben's Lick
1914	Ohio	1.593	2 20	27 80	70 00	30.00	35 28	34 72	Pulverulent	Dark brtish lilac-grey	5 694	Cannel coal or bitumnous shale, H D Bennett's.
1915	Ohio	1 273	5 30	45 70	49 00	51 00	45 00	4 00	Dense spongy	Lilac grey	2 150	Coal, Berry & Walker's land, Muddy Creek.
1916	Ohio	1.305	6 54	37 92	55 54	44 46	51 54	4 00	Light spongy	Light yellowish brown	1 917	Coal, Ben Hines' coal bank (above the clay parting).
1917	Ohio	1 295	4 80	41 00	54 20	45 80	49.14	5 06	Light spongy	Dark lilac-grey	2 356	Coal, Ben Hines' coal bank (below the clay parting).
1918	Ohio	1 384	4 80	35 80	59 40	40 60	45 20	14 20	Spongy	Light lilac grey	3 015	Coal E, on Rough Creek, Mouth of Brush Creek
1919	Ohio	1 340	6 80	32 40	60 80	39.20	52 50	8 30	Spongy	Very light lilac-grey	2 109	L D Taylor's coal
1920	Ohio	1 358	4 80	35 60	59 60	40 40	49 66	9 94	Spongy	Light lilac grey	3 180	Coal D, Brown's coal bank
1921	Ohio	1 357	6 66	33 64	59 70	40 30	51 56	8 14	Light spongy	Lilac-grey	2 768	Wm Warden's coal, near Centretown.
1922	Ohio	1 380	6 00	34 30	59.70	40 30	50 36	9 34	Spongy	Grey-brown	4 307	From Berry & Walker's land, Hines' tract.
1923	Ohio	1 413	2 70	39 30	58.00	40 20	45 90	12 10	Spongy	Grey purplish-brown.	7 959	From A Woodward's bank, on Barrett's Creek.
1924	Ohio	1.310	6 10	37 50	56.40	43 60	50 48	5 94	Spongy	Light-grey	3 002	From Gaines' bank, near Fordsville.
1925	Ohio	1 310	5 54	35 66	58.80	41 20	48 88	9 92	Much inflated	Dark lilac-grey	4 199	From H Dooring's mine.
1926	Ohio	1 282	3 90	40 50	55 54	44 40	52 38	3 16	Much inflated	Lilac grey	2 407	From Henry Thompson's bank (a lower coal).
1927	Ohio	1.348	3 94	37 86	58 20	42 80	50.48	7.72	Light spongy	Lilac-grey	3 128	From Norton's coal bank.
1928	Ohio	1 321	3 70	36 64	59 66	40 34	55.30	4 36	Dense	Light purplish-brown	1.241	From Martin's bank, near Eden Lick
1929	Ohio	1 401	3 20	37.06	59 74	40.26	47 24	12.50	Dense	Dark lilac-grey	6 809	From Henry Davis' mine upper portion).
1936	Owsley	1.794	2.10	35 24	62 66	37 34	58 66	4 00	Spongy	Light lilac-grey	1 424	From Steffee & Samuel's mine, South Fork of Ky. river.
1937	Owsley	1 161	50	59 70	39 80	60 20	32 34	7 46	Dense	Light brown	not est	Cannel coal, Steffee & Samuel's mine, S. Fk. Ky. river.
1938	Perry	1 089	3 10	30 20	61.70	38 30	58 20	3 50	Light spongy	Buff-grey	.836	Coal from Josiah Cobb's bank, near Hazard (upper part).
1939	Perry	1.370	3.70	30 04	65 66	34 34	57.02	8 64	Pulverulent	Grey-buff	654	Coal from Campbell's bank, Mace's Creek
1940	Perry	1.393	2.06	36 74	61.20	38.80	56.32	4 90	Spongy	Brownish-grey	1.436	Coal from R. C. Comb's bank, below Hazard.

1941	Perry	1 888	1 60	36 10	62 30	37 70	56 40	5 90	Light spongy	Light-grey	.836	Coal from Logan's drift, Brashear's salt-works.
1942	Perry	1 274	1.80	40 90	57 30	42 70	53 70	3 60	Light spongy	Brown-grey	1.339	Coal from David Grigsby's bank, Lot's Creek.
1943	Perry	1.290	1 20	40 86	57 94	42 06	46 44	9.50	Dense	Light grey	.634	Coal from D Grigsby's bank, lower part. Cannel coal.
1944	Pulaski	1 357	2.40	36 76	60 84	39 16	50 24	10 60	Spongy	Brownish lilac-grey	2 494	Coal from Cumberland coal banks (Sub-conglrate coal).
1945	Pulaski	1 357	2 00	35 30	62 70	37 30	52 94	9 76	Light spongy	Dark lilac-grey	3 565	Coal from Doolin's bank (a Sub-conglomerate coal).
1947	Rockcastle	1.318	2 00	36 60	61 34	38 66	51 94	9 40	Light spongy	Dark lilac-grey	2 905	Coal from Mynner & Myers' bank, Livingston (Entry 1).
1948	Rockcastle	1 357	2 20	36 50	61 30	38 70	51 70	9 60	Light spongy	Dark lilac grey	4 802	Coal from Mynner & Myers' bank, Livingston (Entry 2).
1949	Rockcastle	1.327	2 20	35 80	61 94	38.06	54 94	7 00	Spongy	Light chocolate	4 302	Coal from Grisham's coal mine (the brashy coal).
1950	Rockcastle	1 374	2 10	39 50	58 40	41 60	49 86	8 54	Spongy	Purplish grey	2 933	Coal from Grisham's coal mine (lower nine inches).
1960	Whitley	n d.	2 84	27 10	7 00	30 00	43 40	26 60	Dense	Purplish grey	2 562	Cannel coal or bituminous shale, Cumberland Falls.
1963	Wolfe	1.336	3 74	35 54	60 74	39 26	52 64	8 10	Spongy	Lilac-grey	2 466	Coal from C M Hanks' bank, Compton
1964	Wolfe	1 434	1.30	41 40	57 30	42.70	28 20	29 10	Pulverulent	Nearly white	840	Cannel coal or bituminous shale, J F Ely's, Gilmore Cr.
1965	Wolfe	1.383	1 16	44 58	54 26	45.74	32.70	21 50	Pulverulent	Light lilac grey	530	Cannel coal? J W Faulkner's, Sullwater Creek.
1966	Wolfe	1.294	3.50	35.20	61 30	38.70	56.70	4 60	Spongy	Lilac grey	1 189	Coal from Hobb's bank, near Compton

TABLE III. IRON ORES (LIMONITES), DRIED AT 212° F.

Number in Report.	County.	Iron peroxide.	Iron carbonate.	Manganese bi'n oxide	Alumina.	Lime carbonate.	Magnesia.	Phos'oric acid.	Sulphuric acid.	Comb'ed water	Silica and silicates	Moisture at 100°.	Per centage of iron	Per centage of phosphorus	Per centage of sulphur	Per centage of silica.	Remarks.
1652	Bath	70.060		not est	4 549	0.040	0 021	1 620	0 031	12 300	11.530		49 042	0 707	0 012	11 530	Slate Furnace ore, "Howard's Hill."
1653	Bath	69 728		not est	8 642	.170	043	1.154	134	12 650	7.930		48.809	504	.053	7.760	Slate Furnace ore (upper part of bed).
1654	Bath	47 321		not est	5 418	690	079	161	376	12 050	33 330	575	33 125	070	.150	27 600	Chalybeate Springs, Pilot Knob.
1655	Bath	39 068	11 479	not est	8 346	18 710	6 159	868	185	7 835	7 350		30 734	379	074	7 560	Near Owingsville (18 to 20 feet thick).
1656	Bath	59 621		not est	12 370	500	144	709	trace	10.400	15 830	426	41 735	.309	trace.	13 960	Old coaling bank, Clear Creek
1657	Bath	66 329		not est	12 532	trace.	173	709	trace	9 580	9.720	.957	46 440	309	trace	9 660	Richardson's bank, Clear Creek.
1658	Bath	65.310		not est	11 947	730	140	.825	trace	11 000	9.580	468	44 570	.360	trace.	9.580	Pergam bank, Clear Creek
1762	Edmonson	40.798			1.293	trace	trace	1.019	360	7 250	50.030		28 559	445	207	46 760	Still house Branch of Bear Creek.
1763	Edmonson	47-744			2 501	trace	trace	697	.325	8 250	41 145		33.407	304	125	39 560	Dismal Creek
1764	Edmonson	49 906			3 330	trace	trace	694	395	9 320	36 780		39 407	303	158	33 460	Sycamore Branch of Bear Creek.
1765	Edmonson	32 820			2.356	trace.	trace.	984	285	8 330	55 180	045	22 974	430	114	48 960	Mill Branch of Bear Creek.
1766	Edmonson	77 871		not est.	1 444	trace	070	505	trace	11 050	8 660	040	54 510	221	trace.	8 660	Cave Branch of Gulf Creek.
1770	Estill	74 127		not est	3 542	.390	401	601	not est	11 270	9.580	029	51 889	262	not est	7 860	From Lustre drift
1771	Estill	65 535		not est	2 798	.450	1 073	537	not est	9.800	20.480		45 874	234	not est	18 260	Logan Ridge limestone ore
1772	Estill	75 398		not est	1 971	540	258	601	not est	11 730	8.910	392	52 918	262	not est	7 260	Tubbs' bank ore
1773	Estill	65 591		not est	5 702	trace	248	.447	trace	11 000	16 230	722	45 914	195	not est	14 100	Horse Ridge ore banks
1794	Grayson	48 913	5 735	not est	7 125	9 410	144	489	199	8 905	19 080		36 526	209	080	16 760	Old Nolin Furnace ore
1862	Lawrence	67 515		not est	1 284	trace	trace	135	.423	10 150	20.480	017	47 250	059	175	16 960	Limestone ore, Upper Blane Creek.
1863	Lawrence	55 603		not est	1 151	trace	trace	284	302	10 510	31.280	780	39 105	124	111	25 660	Red kidney ore, Cherokee Creek.
1897	Menifee	54 750		not est	14 515	trace	047	697	trace	8 600	20.830	559	38 750	304	trace.	19 500	From Branch of Beaver Creek.
1930	Ohio	61 179		not est	5 503	trace	176	648	not est	9 273	13.830		48 825	283	not est	9 960	Alfred Ashby's, Walton Creek.
1931	Ohio	44 594		not est	20 479	trace	248	287	not est	8 560	26 550		31 216	125	not est	23 420	Dooring's iron bank.
1932	Ohio	44 916		not est	13 204	trace	176	280	not est	8 320	32 504		31 241	177	not est	24 460	Same locality
1933	Ohio	15 044		not est	6 113	trace	338	073	not est	6 152	72 280		10.538	032	not est	69 100	Ochreous limonite

TABLE III (A). IRON ORES (CLINTON OR DYESTONE ORES), DRIED AT 212° F.

Number in Report.	State.	Iron peroxide.	Iron carbonate.	Manganese brown oxide.	Alumina	Lime carbonate.	Magnesia.	Phosphoric acid.	Sulphuric acid.	Combined water	Silica and silicates.	Moisture and loss	Per centage of iron.	Per centage of phosphorus	Per centage of sulphur.	Per centage of silica	Remarks.
A	Tennessee . . .	77.380	. .	3 941		0 420	trace	0 319	trace	2 500	15 960	not est	54 166	0 140	trace	15 760	Cumberland Gap; Poor Valley Ridge, upper bed.
B	Tennessee . . .	73 935	. . .	5.776		4.510	266	319	trace	3 850	11 730	not est	51.754	140	trace	11 730	Cumberland Gap; Poor Valley Ridge, upper bed.
C	Tennessee . . .	47.965	. . .	2 130		1.230	194	575	trace	4 000	43 690	not est	33 575	.251	trace	42 760	Cumberland Gap, Poor Valley Ridge, middle bed.
D	Tennessee . . .	80. 840	. . .	not est		not est	not est	not est	not est	not est	not est	not est	56 574	not est	trace	11 260	Cumberland Gap, from Old Clinton Furnace.
E	Pennsylvania .	38.48	*4.37	not est	9.56	†1.06	trace	1 48	.05	4 500	37.99	not est.	30 34	.210	.05	37.99	Dysart's mine, middle bed

* Iron protoxide. † Lime.

TABLE IV. IRON ORES (CLAY IRON-STONES), DRIED AT 212° F.

Number in Report.	County.	Specific gravity.	Iron carbonate.	Iron peroxide.	Alumina.	Lime carbonate.	Magnesia carbonate	Manganese carbonate.	Phosphoric acid.	Sulphuric acid.	Silica and silicates.	Water and loss.	Per cent. of iron.	Per cent. of phosphorus.	Per cent. of sulphur.	Per cent of silica	Remarks.
1769	Estill	not est	76 491	4.049	2 014	5 400	0.514	not est	0.409	0.267	9.330	. .	39 758	0.178	0 107	7 660	Tubbs' bank, near Estil Furnace.
1858	Lawrence . . .	1.352	. .	. . .	not est	. . .	. . .	. . .	. . .	. . .	. . .	. . .	33 264	not est.	.483	7.460	From near Louisa Black Band ore.
1858a	Lawrence . . .	not est	. . .	. .	not est.	. . .	. . .	. . .	. . .	. . .	. . .	. . .	33.923	not est	354	not est	From near Louisa Black Band ore.
1858b	Lawrence . . .	not est	. . .	. . .	17 92	*.924	† 250	. . .	. . .	. . .	. . .	. . .	25 746	.553	. . .	6 36	Louisa Fork Big Sandy river Black [redacted] ore.‡

* Per cent. of lime. † Per cent. of magnesia. ‡ Per cent. of bituminous matters, 13.700: these not estimated in 1858 and 1858a.

TABLE V. PIG IRONS.

Number in Report.	County.	Specific gravity.	Iron.	Graphite	Combined carbon	Manganese	Silicon	Slag	Aluminum.	Calcium	Phosphorus.	Sulphur	Total carbon.	Remarks.
1659	Bath	7 007	92 631	3 840	0 710	not det	1.580	0 100	not det	0 090	0.363	0 278	4 550	Cold blast No 1 charcoal, Bath Furnace.
1660	Bath	7 067	92 056	3 640	310	not det	1 760	100	not det	.116	1.080	.218	3.950	Old Slate Furnace
1661	Bath	7.142	93 106	3 860	590	not det	.914	160	not det	not det	.527	.011	4 45	Cold blast No 1 charcoal car wheel, Cot Fur.
1662	Bath	7 017	91 924	3 440	1 000	not det	1 319	260	not det	not det	.220	107	4.50	Cold blast No 2 charcoal, Bath Furnace
1663	Bath	7.092	93 472	3 100	1.510	not det	.652	160	not det	not det.	.290	.121	4 610	Cold blast No 3 charcoal Bath Furnace
1664	Bath	7 168	93 004	2 700	1 410	not det.	1 007	.260	not det	not det	120	.172	4 120	Cold blast No 4 charcoal, Bath Furnace.
1700	Boyd	6 921	92 962	2 100	1 310	not det	2 525	220	not det	not det.	.568	.114	3 410	Hot blast mill iron Bellefonte Furnace
1701	Boyd	6.163	89 902	2 900	070	not det.	5 082	.280	not det	not det	417	.114	2 970	Hot blast silver grey, Bedefonte Furnace.
1716	Carter	6 930	93 268	3 950	770	not det	1.799	160	not det	not det	680	.081	4 720	Hot blast mill iron, Mt Savage Furnace
1717	Carter	7.042	91 584	2 600	1 070	not det	3 058	.620	not det	not det	609	.152	3 670	Hot blast foundry No 2 Mt Savage Furnace.
1718	Carter	7 435	89 087	2 300	500	not det	5 575	600	not det	not det	.609	.136	2 800	Hot blast silver-grey, Mt Savage Furnace.
1774	Estill	7 168	93 728	3.520	780	.389	1.202	300	.264	not det	290	.080	4 300	Cold blast No 3 charcoal, Red River Furnace.
1775	Estill	not est	93 963	2 000	2.550	.181	363	.320	648	not det.	.338	104	4 550	Cold blast No 5 charcoal, Red River Furnace.
1776	Estill . .	7 226	94 174	3 340	1 110	not det	.447	.360	not det	not det	.402	182	4 450	Cold blast No 1 charcoal car wh'l iron R R. F.
1777	Estill . . .	7 272	92 582	3 500	1 200	not det.	960	.300	not det	not det.	444	.066	4 700	Cold blast No 2 charcoal car wh'l iron, Estill F.
1801	Greenup . . .	not det	92 284	2 960	690	not det.	3 011	.880	not det	not det	474	not est.	3 650	No 1 foundry iron, Hannewel. Furnace.
1802	Greenup . .	not det	90 630	2 500	.830	not det	4 969	.360	not det	not det	.741	040	3 330	No. 1 hot blast silver-grey Pennsylvania Fur.
1803	Greenup . .	not det	92 060	2.700	630	not det	3 104	.300	not det	not det.	.710	.033	3 330	No 2 foundry iron, Pennsylvania Furnace.
1804	Greenup . . .	not det	94 764	2 900	.780	not det	1 193	200	not det	not det	.860	.033	3.080	Mill iron, Pennsylvania Furnace
1805	Greenup .	not det	92 856	3 230	. .	not det	2 545	.360	not det	not det.	817	.046	3 230	No 3 foundry iron, Pennsylvania Furnace
1806	Greenup	6 680	92 897	2 100	1 000	not det	1.813	not est	not det	not det	.454	218	3 100	No 2 cold blast iron, from blue ore, Laurel F.
1807	Greenup . .	6 927	91.596	2 900	.250	not det	3 417	.800	not det	not det.	247	.237	3 150	Hot blast mill iron, stone coal, Raccoon Fur.
F	Tennessee . . .	not est	92.828	3.260	.840	.153	1 668	.480	.766	119	.145	.068	4.100	From Clinton ore, Old Clinton Furnace.

TABLE VI. CLAYS, DRIED AT 212° F.

Number in Report.	County	Silica and silicates.	Silica	Alumina.	Iron oxide	Lime.	Magnesia	Phosphoric acid.	Sulphuric acid.	Potash.	Soda.	Water expelled at red heat	Remarks.
1697	Boone	.	48 360	33 060		3 057	0 367	not est	not est	4 664	1 706	8 786	Clay from near Burlington
1767	Edmonson	.	80 160	12 600		.760*	560	not est	not est	3 854	583	2 483	Clay from Sowder's farm.
1768a	Edmonson	.	77 660	16 800		480*	not est	not est	not est	1 002	484	4 340	Clay from Sowder's farm (the upper part).
1768b	Edmonson	.	74 460	20 440		640*	not est	not est	not est	not est	not est	4 460	Clay from Sowder's farm (the second part).
1768c	Edmonson	.	71 560	22 860		680*	not est	not est	not est	not est	not est	4.900	Clay from Sowder's farm (the third part).
1768d	Edmonson	.	67.560	22 540		980*	672	025	. .	2 470	058	5 690	Clay from Sowder's farm (the lowest part).
1873	Lincoln	.	61 580	23.946	5 814	201	.850	not est	not est	1 542	362	5 705	Clay from head waters of Green river
1876a	Madison	.	59 976	27 640		280*	606	not est	not est	3 931	547	7.020	Potter's clay (Upper Silurian), Waco
1876b	Madison	.	56 960	28 740		200*	.752	not est	not est	2 501	315	10 551	Potter's clay (Upper Silurian), Waco.

* Carbonate

TABLE VII. MARLY SHALES; MARLS AND SILICIOUS CONCRETIONS, DRIED AT 212° F.

Number in Report.	County.	Silica and silicates.	Silica	Alumina	Iron oxide	Lime carbonate	Lime	Magnesia carbonate	Magnesia	Phosphoric acid	Sulphuric acid.	Total potash	Total soda.	Water, &c.	Remarks.
1665	Barren	8 860	. .	5 800		66 160	. . .	24.083	. .	not est	not est	. .	5 097	. .	From Proctor's Cave
1741	Clinton	. . .	70. 800	18 840		. . .	0. 394	. . .	4. 358	not est	not est	4 240	794		From Cumberland City Mines.
1788	Grayson	74 360	. . .	14 452		1 60	. . .	. . .	1. 715	1 089	not est	4 240	948	7.000	Nodular ferruginous clay, Bear Creek.
1789	Grayson	68 380	. . .	12 452	7 588	1 380	. . .	. . .	1. 643	not est	not est	5 049	1 060	8 250	Nodular ferruginous, Canolaway Creek.
1790	Grayson	44.760	. . .	26 892		9 160	. . .	6.629		1 089	not est	4.944	2.061	6.136	Marly shale below limestone, Hot Branch, Bear Creek.
1791	Grayson	59 920	. . .	27 812		880	. . .	. . .	.824	.109	not est	5 554	657	4 245	Marly shale, Haycraft's Lick
1792	Grayson	58 362	. . .	25 758		1. 580	. . .	. . .	4.437	102	not est	5 145	.347	3.671	Red marly shale, Haycraft's Lick
1793	Grayson	60. 760	. . .	23 072		1. 180	. . .	. . .	.497	089	not est	4 693	438	9. 872	brown marly shale, Cedar Knob Lick.
1864	Lawrence	80 660	. . .	1 800		.260	. . .	. . .	. . .	not est	not est	not est	not est	3 88	Carbonaceous matters 13 40. Petrifaction.

APPENDIX.

THE CLINTON IRON ORE. DYESTONE ORE OF TENNESSEE. FOSSIL ORE.

In consequence of the great abundance of this valuable ore in the mountainous region of Tennessee, very near to the Kentucky line, and in view of the proximity of Kentucky coal beds to these ore beds, the members of the Geological Survey collected some characteristic average samples from them, which have been analyzed, with the following results:

A. "*Clinton Ore; upper bed, in Poor Valley Ridge. Cumberland Gap, Tennessee. Average sample from a number of exposures of the beds. By P. N. Moore. Clinton Group.*"

A soft ore, easily breaking into irregular laminæ or scales; filled with small disc-formed concretions or fossil casts. Powder of a blood-red color.

B. "*Clinton Ore; upper bed. Foot of Poor Valley Ridge, on a branch down from the Virginia Road. Cumberland Gap, Tennessee. Collected by P. N. Moore.*"

Very much like the preceding.

C. *Clinton Ore. Middle bed of the ore; twenty-six inches thick. Cumberland Gap, &c. Collected by P. N. Moore.*"

Harder and more compact than the preceding; containing but few fossil-like concretions or casts. Externally of a brownish-ochreous appearance. Powder of a light reddish-brown color.

D. "*Dyestone Ore, from near Cumberland Gap, Tennessee. From old Clinton Furnace. Clinton Group.*"

For comparison with the above, the analysis of a similar ore from Pennsylvania, analyzed by Professor Persifer Fraser, of the University of Pennsylvania, is appended.

E. *"Hard Fossil Ore, or Clinton Ore. Middle bench of Drysart's mine. Pennsylvania."*

COMPOSITION OF THESE CLINTON ORES, DRIED AT 212° F.

	A.	B.	C.	D.	E.
Specific gravity	3.942	3.914	3.190	....	....
Iron peroxide	77.380	73.935	47.965	80.820	38.48
Iron protoxide	....	...	....	....	4.37
Alumina }	3.941	5.776	2.130	....	9.56
Manganese oxide }					not est.
Lime carbonate	.420	4.510	1.230	....	*1.06
Magnesia	a trace.	.266	.194	....	a trace.
Phosphoric acid	.319	.319	.575	....	1.48
Sulphuric acid	a trace.	a trace.	a trace.	....	†.05
Combined water	2.500	3.850	4.000	....	4.500
					‡2.54
Silica and insoluble silicates	15.960	11.730	43.690	....	37.99
Total	100.520	100.386	99.784	....	100.00
Per centage of iron	54.166	51.754	33.575	56.574	30.34
Per centage of phosphorus	.140	.140	.251	....	.21
Per centage of sulphur	a trace.	a trace.	a trace.	....	.05
Per centage of silica	15.760	11.730	42.760	11.260	37.99

*Lime. †Sulphur. ‡Alkalies.

Professor J. P. Lesley, Chief of the Pennsylvania Geological Survey, states that the iron produced from this ore is always "cold-short," but that it is valuable to work with richer and less fusible ores. This is the character of this ore in other localities, and it appears to have a wide range, extending even into Wisconsin. But the samples examined in this laboratory do not yield as much phosphoric acid as the usual average of this ingredient; and from experiments which have been made in smelting this Tennessee ore, it is believed that a good tough iron can be made from it.

F. *A sample of the Pig Iron made at the furnace at the Cumberland Gap, from the Clinton Ore, was obtained by Mr. P. N. Moore, and analyzed.*

The iron is fine-grained mill iron? It yields with difficulty to the file, but extends under the hammer a little more than is usual with pig iron.

COMPOSITION OF THIS CLINTON PIG IRON.

Iron	92.828	
Graphite	3.260	Total carbon = 4.100.
Combined carbon	.840	
Manganese	.153	
Silicon	1.668	
Slag	.480	
Aluminum	.766	
Calcium	.112	
Magnesium	.270	
Phosphorus	.145	
Sulphur	.068	
	100.590	

It will be seen that this iron will compare favorably with the best quality of pig metal.

G. *"Coal from Winter's Gap, near Knoxville, Tennessee."*

In a valley about ten miles from the Cincinnati Southern Railroad. The bed is said to be seven feet thick, and three acres of it have been mined out without leaving a pillar. Said to be the best pit coal in Tennessee. The sample was presented by Gen. Winder at the Centennial Exhibition. It is quite a pure-looking, firm, pitch-black, glossy coal; not breaking into thin laminæ; having no apparent fibrous coal, and very little granular pyrites.

COMPOSITION, AIR-DRIED.

Specific gravity	1.256		
Hygroscopic moisture	1.64	Total volatile matters	38.40
Volatile combustible matters	36.76		
Spongy coke	61.60	Fixed carbon in the coke	59.90
		Carrot-colored ash	1.70
	100.00		100.00

The per centage of sulphur is . 1.450

This is a coal of remarkable purity, leaving a smaller proportion of ash than any coal examined during the Geological Survey of Kentucky. Of course it cannot be considered an *average* sample of the bed, yet it is evidence of its superior quality. The proximity of this bed of coal to the Cincinnati Railroad makes it matter of interest to our citizens.

GERMAN GLASS POT FIRE-CLAY, AS COMPARED WITH SAMPLES OF KENTUCKY CLAY.

On a recent visit to the great International Centennial Exhibition at Philadelphia, the attention of the writer was attracted by an exhibit of this fire-clay, supposed to be one of the most refractory known, and imported for the construction of crucibles to withstand a very high heat, but particularly for our glass manufacturers, who seem to agree that no other known clay will so completely withstand the great heat of their furnaces, and the fluxing influence of the melted glass, as this. It is consequently almost universally used by them as the material for the construction of the glass pots or large crucibles, in which the glass is made and melted.

The exhibit of this clay at the Centennial Exhibition was made by J. Goebel & Co., importers of German clay, and manufacturers of crucibles, &c., Maiden Lane, New York. It showed the clay in its natural and prepared conditions; and accompanying the specimens was a report of the chemical analysis of the material, said to have been made in Germany, a copy of which is appended.

With a view to study this valuable clay, in comparison with some Kentucky samples from our coal measures, the writer secured a sample from what appeared to be a washed and prepared specimen on exhibition, which had been moulded into a cubical block, and which he has analyzed.

H. *The Clay is of a light grey color; adheres strongly to the tongue; and exhibits a large irregularly conchoidal fracture. Before the blow-pipe it fused only on the extremity of the small pointed fragment, into a white slag.*

I. *Another specimen of this German Glass Pot Clay was obtained at the Co-operative Window Glass Works, at the foot of Coal Hill, opposite Pittsburg (near the inclined railroad). The pot-maker, who furnished the sample from a partly used barrel of the material, stated that it was in the condition in which it was imported from Germany.*

This had not been re-worked or washed. It resembles the preceding, but is a little more friable, and slightly lighter colored. Its powder, however, is somewhat darker than the powder of that. Before the blow-pipe it acted like that.

J. *Copy of the analysis of this clay made in Germany, as exhibited by J. Goebel & Co.*

For comparison with these, I append a copy of the analysis of some clay from Carter county, Kentucky (see volume I, Kentucky Geological Reports, new series, page 179, lower paging), labeled—

"No. 1337—*Fire-clay; average sample from the upper bed, four feet thick, on both sides of the hill. Ridge between Grassy and Three Prong Creek. Boone Furnace property. Whole bed eight to ten feet thick. Collected by P. N. Moore.*"

This clay, forming a heavy stratum, is in a compact state—so hard as scarcely to be scratched with the nail; breaking into angular fragments. It is of a light-grey color, and becomes plastic when reduced to powder.

COMPOSITION OF THESE FIRE-CLAYS, DRIED AT 212° F. (Except J, which seems to have been more thoroughly dried).

	H.	I.	J.	No. 1337.
Silica	*70.860	†73.660	70.60	48.560
Alumina	20.900	19.460	23.60	37.471
Iron oxide (calculated as peroxide)	1.560	1.560	. . . . .	a trace.
Iron sulphide	. . . . .	. .	1.10	. . . . .
Lime	.347	.168	.36	.112
Magnesia	.220	.209	.45	a trace.
Phosphoric acid	not est.	not est.	not est.	.255
Sulphuric acid	not est.	not est.	not est.	not est.
Potash	.578	.520	not est.	.289
Soda	.112	.046	not est.	.283
Water expelled at red heat	6.800	6.200	‡3.89	12.030
Total	101.377	101.823	100.00	99.000

*Including about four per cent. of fine sand.
†Including about three and a half per cent of fine sand.
‡Organic matters and loss.

The iron peroxide obtained in the analyses of H and I was doubtless derived from iron sulphide in the clay. The apparent excess is probably due mainly to fixed alkalies in the pre-

cipitated alumina, which may be estimated correspondingly too high.

The large proportion of silica in the German clay (a part of which is in the state of fine sand) is notable in comparison with the Carter county clay; and this large proportion of silica or sand increases the refractory quality of the clay. But pure fine sand or pulverized quartz could quite cheaply be added to our clay, which, in other respects, seems to be at least equal in quality as a fire-clay to the German article, containing even less of those ingredients which increase the fusibility of clay, viz: iron oxide, lime, potash, soda, and magnesia. How the phosphoric acid acts in this relation is said not to have been fully determined by experiment; but it undoubtedly increases the fusibility. As will be seen, the proportion of this ingredient was not ascertained in the German clay, although it is no doubt present in notable quantity.

There can be little doubt that some of our native fire-clays can be made quite refractory by a judicious process of preparation or purification, including, perhaps, washing with water, or water containing chlorohydric acid, which is very cheap, the addition of pulverized quartz, &c.

In this relation we may notice a beautiful hydrated silicate of alumina—the Indiana kaolin, or what is denominated *Indianaite* by Prof. E. T. Cox, of the Indiana Geological Survey—a large and handsome sample of which was exhibited at the Centennial. This remarkable clay-like mineral, which was discovered first in Illinois, and called Golconda clay, was found in Lawrence county, Indiana, in 1875, forming a six feet bed, just under the coal measures conglomerate, and over a bed of brown hematite iron ore. Where it has not been impregnated with iron oxide it is a pure hydrated silicate of alumina, of the composition of halloysite, passing in its greenish portions into alophane.

This so-called porcelain clay soon attracted the attention of potters, and is now in great demand for the manufacture of the finer qualities of pottery ware. The writer believes, however, from the brief examination he has given it, that it de-

serves a more exalted application, being, when pure and free from infiltrated iron oxide and lime, more refractory before the blow-pipe than any clay he has examined. It is therefore believed that it might find a more suitable application in the manufacture of the most refractory crucibles, and that, when mixed with pure fine sand or pulverized quartz, it might very well answer for glass pots.

The general composition of the white variety, as reported by Prof. Cox (Geological Report of Indiana, 1874, page 18), is as follows:

Silica	45.90
Alumina	40.34
Lime	trace.
Water	13.26

A specimen of this mineral, obtained by the writer from that exhibited at the Centennial (beautifully translucent; nearly white, with a slight greenish tint), when examined for fixed alkalies, gave 0.198 per cent. of *potash*, and 0.204 of *soda*, when dried at 212 F. It was not examined for alkaline earths or phosphoric acid.

This mineral, which may be made so useful in the arts, may doubtless be discovered in Kentucky in a similar geological position with that in Indiana.

GEOLOGICAL SURVEY OF KENTUCKY.

N. S. SHALER, DIRECTOR.

REPORT

ON THE

GEOLOGY OF MENIFEE COUNTY,

BY A. R. CRANDALL.

PART II. VOL. IV. SECOND SERIES.

167 & 168

REPORT ON THE GEOLOGY OF MENIFEE COUNTY.

Menifee county has an area of about two hundred square miles. It reaches from the Licking river to Red river, along the Morgan and Wolf county lines, on the east and southeast, and extends, in a narrowed and somewhat irregular outline, into the valley of Slate creek, to the westward. As will be seen from the accompanying map, the drainage of the county is effected by Beaver creek and its branches; by Salt Lick, the head waters of which are within the county, forming a valley that leads into Bath county on the north; by Clear Fork, Hawkins Branch and other branches of Slate creek, which rise in the western part and flow into Montgomery; by the greater part of Indian and Gilladie creeks, tributaries of Red river, on the south; and by some of the branches of Blackwater creek on the east. The Licking river forms the boundary from the mouth of North Fork to the mouth of Beaver creek, and drains a narrow belt along its tortuous course.

The area of the county is therefore made up of several drainage basins that open outward from the central part. These basins or main valleys are bounded by high ridges, which, together with the almost numberless minor ridges and spurs that determine the local drainage, cover a large part of the area, the main valleys being a complicated system of drainage by multiplied ramifications of narrow valleys, rather than basins, with broad bottom lands.

Geologically the county is stretched across the outcrop of the lower members of the coal measures, and nearly across the belt of the Lower Carboniferous rocks, as represented by the Sub-carboniferous limestone and the Waverly shales and sandstone. This fact, more than any other, carries with it the explanation of the character of the surface, as already de-

scribed; for it brings the hard Conglomerate sandstone of the coal measures in that relation to the surface of the country which makes it the most important factor in the determination of the character of the drainage. The result is what has been described. A general inclination of the rock beds to the east and southeast varies somewhat the results of erosion, as represented by the valleys in the different parts of the county; but the variation is one of degree rather than of kind; for the type of valley, as seen in the middle and eastern part, where the ridges are broad and the cliffs of Conglomerate hem in the narrow valleys, is still preserved on the head waters of Slate creek, where the Conglomerate cliffs, capping the hills, preserve the steepness of the hillsides, and continue the system of ridges and spurs, but with narrowed tops and broader valleys, out into the belt of the Lower Carboniferous rocks. The cliff-making, Sub-carboniferous limestone below the Conglomerate, although no more than forty to sixty feet thick, serves to extend this system beyond the present boundary of the Conglomerate.

The causes which lead to the disposition of the main valleys in a somewhat radiate order, are also closely connected with the geology of the region. Between the hard magnesian and cherty limestone of the Upper Silurian, and the cliff-making, Sub-carboniferous and coal-measure rocks, about five hundred feet, mostly of shaly rock, is interposed—the Devonian black shales and the Waverly shales and sandstone. As might be supposed, this gives rise to a broad valley, having for its boundary the inclined Silurian beds, on the one side, and the receding edges of the Waverly beds, capped by the harder rocks above, on the other side.

Long-continued erosion has widened and diversified this valley, cutting in advance of the receding crests of limestone and conglomerate the smaller valleys that head against Beaver creek and Salt Lick. Thus, the dividing ridge between Slate creek and these streams has come to have a north and south direction, rather than northeast and southwest—the general direction of the line of outcrop. But this

main ridge terminates southward in another main ridge, having its general course east and west, from which the waters of Slate and Beaver flow northward, and the tributaries of Red river southward. The westward extension of this ridge is a continuation of the boundary of the Devonian and Waverly valley already described. The eastward extension, as also the sudden change in the direction of the boundary of Slate creek valley, is explained by another set of conditions. Variations, both in the direction and the steepness of the inclination of the rock beds, becoming important factors in the determination of the direction of the drainage along this ridge. The general eastward dip of all the rocks in this region is modified by a depression which coincides in general with the Red river valley, and also by a slight depression in the direction of the Licking river. This east and west ridge follows the crest of an undulation which has its axis nearly at right-angles to the general outcrop line of the coal measures. It represents an elevation along which the coal-bearing rocks are preserved to the westward, somewhat beyond the general boundary of these rocks, and at the same time it reduces the width of the valley that lies between the coal-measure and the Silurian rocks.

The exact amount and the details of the variation from the general eastward inclination of the several rock formations found in Menifee have not been ascertained, the limited time and means at command forbidding any attempt at accurate measurement. The depression and consequent dip towards Red river is apparent to the most casual observer. That towards the Licking is less noticeable. Mr. Joseph Leslie, in giving the results of his observations, made under the direction of Professor Owen,* speaks of a number of undulations of the rock beds along the outcrop of the coal measures corresponding generally with the drainage basins leading to the westward. A profile section drawn by him illustrates this feature, and gives approximate measurements of these undu-

*Volume IV, page 456, old series.

lations. Not having an opportunity to study this profile section, it can only be referred to in this report in general terms.

These waves, at right-angles to the outcrop, doubtlessly anticipated the drainage of the country by the formation of geological valleys. The thickening of the beds above the Conglomerate to the eastward, and, finally, the change of the general dip, has caused the drainage to be westward along these geological valleys. In this last respect the thickening of the coal measures east and southeastward is more important, as a factor, than it has been heretofore recognized to be; but as few of the facts that come under this head are found in Menifee, it is only necessary to refer to it in this report.

The Lower Carboniferous belt, as shown in this county, is not entitled to particular notice, except in connection with the topography; and under this head the descriptions already published will suffice to give the general reader a clear notion of the relation of the rocks which it represents to the various economic questions involved. (See report of Mr. Lesley on the topography and geology of the country along the outcrop line of the eastern coal fields, volume IV, old series; also report on the geology of the proposed line of the Elizabethtown, Lexington and Big Sandy Railroad, from Mt. Sterling to the Big Sandy river, volume II, second series.) A glance at the accompanying profile section will show the relation of the rocks of this belt to those of the coal measures above, and also to those of the Devonian and Silurian ages below. The section is drawn to illustrate, in a general way, the succession of beds as found in Menifee and the adjoining counties to the northeast and southwest, and more especially to show the geology along a line from Jeffersonville, in Montgomery county, by Frenchburg, to Blackwater creek, near Sexton's Mill. The section is necessarily somewhat diagrammatic, the thickness of the various beds not having been ascertained at all points along the line. It is still more so as to the rocks below the drainage, the thickness being assumed to be the same as where exposed. The representation is made to aid those who have not been accustomed to trace the rocks

below the surface. It should also be stated that the profile is largely diagrammatic for the Blackwater region, the plan for having a complete survey of Menifee not having been carried out.

The coal measures, as shown in the western part of the county, are represented by a shale series and by the Conglomerate sandstone. The former has come to be known as the Sub-conglomerate shale formation, and the coals found in these beds are known as the Sub-conglomerate coals. In this report the term is used without reference to any general classification of the Carboniferous rocks of this field.

In Greenup and Carter it was found that these shales were present, though not always separated from the shales above the Conglomerate, the Conglomerate sandstone being entirely wanting near the Ohio river, in places, but becoming prominent to the southwest.* In that region the lower limestone ore, a thin coal, and a thick bed of non-plastic fire-clay, are included. In this region this shale series is much more prominent; and being surmounted by a great mass of Conglomerate sandstone, it includes nearly all the productive coal and iron-bearing rocks of Menifee.

The fire-clay bed seems to have fallen off in importance in proportion as the Sub-conglomerate shales become more prominent, the only trace of it in this region, so far as known, being an occasional fragment found upon the surface. These fragments may lead to the discovery of local deposits of this clay. On the other hand, the coal deposits are increased in something like the same proportion. This increase does not always carry with it a corresponding increase in economic values, as will be seen by reference to sections 3 and 4, plate 1 (section plates accompanying this report), in which the number of beds is increased without adding greatly to the thickness of workable beds. Generally, however, the deposit is found mostly in a single bed of what proves to be an exceptionally pure coal of workable thickness.

*Report on the geology of Greenup, Carter, and Boyd counties, and a part of Lawrence, volume II, new series.

The limestone ore bed also proves to be an important deposit, both from the quality and the abundance of the ore. Whether the close association with a coal, apparently well adapted to the smelting of iron ore, gives an additional economic value to both the coal and ore, remains yet to be determined by practical experiment.

The nearness to market is an important factor in any view of the economic value of the coal of this region. Already reached by the narrow-gauge railroad from Mt. Sterling, this field ought, from all the conditions of the case, to supply a large part of Central Kentucky with fuel, and that, too, at much more reasonable rates than has been heretofore exacted, until the heavier deposits of more remote regions are reached by this or other railroads; and even then the nearness to market will warrant a competition with more distant fields, until the best deposits of this region have been exhausted. For the same reasons, the Slate creek coal region is of more immediate importance than that of the central part of the county, although the actual coal area on Slate creek is comparatively small, the coal being found near the tops of the narrow ridges. (See profile section.)

Sections 1 and 5, plates 1 and 2, show the position of the main Sub-conglomerate coal, and also the thickness at the two points indicated. The outcrop of this coal is found at this level, wherever the rocks of this horizon are exposed, in the Slate creek valley. Not being mined, or being opened for local use only by benching, the thickness is rarely shown. It is probable, however, that an average thickness like that at the head of Bull Fork will be found in this region, including the main ridge between Slate and Indian creeks, and between Slate and Beaver.

In this valley the limestone ore is not exposed as frequently as further to the eastward, although there is good reason to suppose that it will be found, in its usual variable thickness, at the top of the Sub-carboniferous limestone, over the most of this region. As yet, no effort has been made to determine the value of this ore in this valley, fragments upon the surface

being the only means of judging as to the range of the bed, as also, for the most part, of the thickness.

Sections 2, 3, and 4, plate 1, show a considerable variation in the character and thickness of the Sub-conglomerate series on Indian and Gilladie creeks. At the head of Indian creek the thickness continues to be about the same as on the head waters of Slate, while near the Red river and in the ridge eastward, between Gilladie and Beaver creeks, an increased thickness is found, and also an increased number of coals. Near the mouth of Indian creek, in Powell county, the thickness of the Sub-conglomerate shale series exceeds one hundred feet. Near the mouth of Gilladie creek the shales measure one hundred and twenty-five feet, as shown in section 4.

Section 3, on the farm of Green Gibbs, on Muddy Fork of Indian creek, shows a local feature that has been thought to promise better results from coal mining than elsewhere in this region. A considerable thickness of highly bituminous shale, in some parts an impure coal, gives to the unpracticed eye the appearance of a heavy coal deposit. Nearly the same feature, but in less thickness, is shown on one of the branches of Leatherwood Fork of Indian creek, a little to the westward. At the head of Cane creek a considerable thickness of cannel slate is found at the base of the shale series. There appears to be nothing in these beds to warrant any expectation of local deposits of exceptional value. On the contrary, it may be found that the impure coal of this locality is the equivalent of the coal of section 1. If this should prove to be the fact, then the area of the workable coal would be somewhat reduced. This feature appears to be local, however, and the main coal in workable thickness is found at the head of Leatherwood Fork, and also at a number of points on East Fork of Indian creek.

The sections on Gilladie creek show an increased number of coals, and a change in the relative position of the main bed. Whether this last fact is owing to a decrease in the importance of the coal of section 1, or to an increase in the

thickness of the shales below this coal, is not made clear from the facts at hand. It is quite probable, however, that one of the upper beds is the equivalent of the Bull Fork coal. No openings have been made in this locality to determine the real thickness of these beds. The exposures are such, however, as to show that the upper beds only may be expected to prove valuable.

Near the mouth of Chimney-top creek, in Wolfe county, a section similar to section 4 is found. Coal of very superior quality has been shipped in small quantity to Mt. Sterling from the upper beds. The coal was obtained by benching. No authentic information has been gathered as to the exact thickness of the beds, which are now mostly covered.

The limestone ore is present in all this region, as is shown from the fragments on the surface. It is exposed in large blocks, particularly on the left fork of Gilladie creek, and in the ridge between Middle and Leatherwood Forks of Indian creek. Specimens have been sent in for the State cabinet.

Sections 6 and 8, plate 2, show the extremes in the thickness of the Sub-conglomerate shales in the valley of Beaver creek. A comparison with the sections near the Red river shows a decrease in thickness northward from that river; but it will be seen that, north of the main east and west ridge (known as Dry Ridge), the place of the main coal is the same as at the head of Slate creek, and that the decrease in the thickness of the shales is from the absence of the upper beds; the coal on Brushy creek, near Old Beaver Furnace, being immediately under the Conglomerate cliff. Further to the northeast, in Morgan county, this coal is again separated from the Conglomerate sandstone by shales. South of Dry Ridge, as has already been stated, the increase in the thickness of the shales appears to be mostly below the main coal. The evidence on this point is somewhat conflicting. It is an important matter only as it relates to the more general question of the equivalency of the coal beds to the south and southwest, where the Sub-conglomerate shales become still more

prominent. It was the opinion of Mr. Leslie* that the lower part of the Conglomerate, changed in character to shale and shaly sandstone, and containing several beds of coal, contributes to the thickness of the Sub-conglomerate beds in this direction. In Menifee the variation in thickness of the Sub-conglomerate shales is not accompanied with a corresponding variation in the thickness of the Conglomerate sandstone. On the contrary, in the Red River valley, where the shales are the most prominent, the Conglomerate is also at its maximum thickness, as shown near the mouth of Gilladie creek, the Conglomerate being more than 200 feet thick at this point, the shales reaching 125 feet, and including four coal seams, the number reported by Mr. Leslie to the southwest.

It will be noticed that the position of the cannel coal in sections 3 and 4 indicates a thickening of the lower part of the shale series. On the other hand, the coal in section 6, near the base of the shales on the Beaver creek side of the ridge, appears to be the equivalent of the Bull Fork and Hawkins Creek beds, sections 1 and 5.

In the valley of Beaver creek, except perhaps along Dry Ridge, where the shale series is in considerable thickness, only one coal bed of importance will be found. The sections of plate 3, together with those already referred to, show the position of this bed. In thickness it is not uniform, varying where exposed from twenty inches to thirty inches, at the outcrop.

The limestone ore is exposed at a great number of places in Beaver Creek valley. In the immediate region of Old Beaver Furnace it was formerly opened and worked. (See sections 13 and 14, plate 3.) In the region of Clear Creek Furnace it is now obtained in abundance for furnace supply. (See sections 7, 12, and 15.) The region near the head of Beaver creek promises, so far as surface indications go, to become a more important iron ore region than the localities already mentioned. Sections 6, 9, and 11 show the surround-

*See report on the Topography and Geology of the Western Margin of the Eastern Coal Field of Kentucky, vol. IV, old series, page 454.

ings of this bed as noted in this region. On the Old State Road branch, above Frenchburg, the ore is particularly abundant on the surface, as also at some points along the face of the ridge between the upper Beaver valley and the head of Salt Lick.

Section 10, near the head of Beaver creek, and section 16, near the mouth of the same creek, show a feature which is not uncommon in the Sub-carboniferous limestone of this region—a bed of so-called lithographic limestone, varying from a few inches to two feet in thickness. In the latter region this band is exposed at a number of points; and from Mr. McMurtry's quarry, on the opposite side of the Licking river, blocks were some time since obtained and tested for lithographic use, with satisfactory results. The band is not so uniform in quality, where seen, as to insure equally good results without careful selection.

The valley of Salt Lick is not properly within the coal region, the westward boundary ridge being entirely Sub-carboniferous and Devonian. But the main ridge, between Salt Lick and Beaver creek, is capped by the Conglomerate sandstone with the underlying coal and iron-bearing shales, giving to this valley whatever advantages the coal and iron deposits of this ridge may offer. On Clear creek, a branch leading against this ridge, an iron industry has already sprung up, Clear Creek Furnace having been in successful operation for years previous to the late financial crisis. (See report of Mr. Moore on the Geology of the Red River Iron District.)

East of the Beaver Creek basin the Sub-conglomerate beds are below the drainage, except near the Licking river. Most of that part of Blackwater creek which is within Menifee has its bed in the Conglomerate sandstone. The Sub-conglomerate beds are, therefore, of little economic value east of the Beaver Creek valley. In this part of Menifee the hills are capped by the shales above the Conglomerate. (See profile section.) These shales usually include one or two coals. In this belt no coals of considerable thickness have been observed. Eastward, in Wolfe and Morgan counties, the Con-

glomerate falls below the drainage, and the whole height of the hills is made up of the rocks of the productive coal measures.

The following table of analyses by the chemists of the Survey, Dr. Peter and Mr. Talbutt, shows the quality of the Menifee coal. The analyses were made from samples carefully taken to represent the whole thickness of the bed at the several points:

	Adams' Bank, Old State Road, Branch of Beaver Creek.	Hawkins' Creek Coal.	Brushy Creek, Steele's Bank.	Bull's Fork Coal, Main Bank.
Moisture	5.00	2.94	3.80	5.00
Volatile combustible matter	32.40	33.06	38.60	39.06
Fixed carbon	58.40	56.60	52.00	55.94
Ash	4.20	7.40	5.60	2.76
Sulphur	.614	.997	not determ'd.	1.199
Specific gravity	1.300	1.319	1.301	1.300

SOILS.

The soil of Menifee is mostly sandy loam. Where the shales below or above the Conglomerate supply the greater part of the surface material, the soil is more clayey. The disintegration of the Conglomerate sandstone, the most prominent rock of the greater part of Menifee, gives to the soil a large per cent. of coarse sand. The presence of the Subcarboniferous limestone, no doubt, adds considerably to the richness of the soil of the valleys where it is exposed; while the woodlands, which comprise by far the greater part of the county, are rich in vegetable mould. The unevenness of the surface is unfavorable for extensive tillage. Pasturage should become an important part of husbandry in this region. The steep hillsides are particularly unsuited to tillage. Rich in vegetable mould when first cleared of timber, it takes but a few years of plowing and washing to render them barren, and, for a time, nearly worthless. When this result has been reached, it is too late to seed for pasture. With the system, or want of system in farming, that tends to this result, there is nothing to do but to clear another tract, and to sacrifice it in the same way. It is largely owing to this way of farming

that the apparent barrenness of the hill country, where cleared, so belies the natural fertility of the soil. Well directed enterprise in farming would do very much to offset the disadvantages of a hilly and broken surface.

TIMBER.

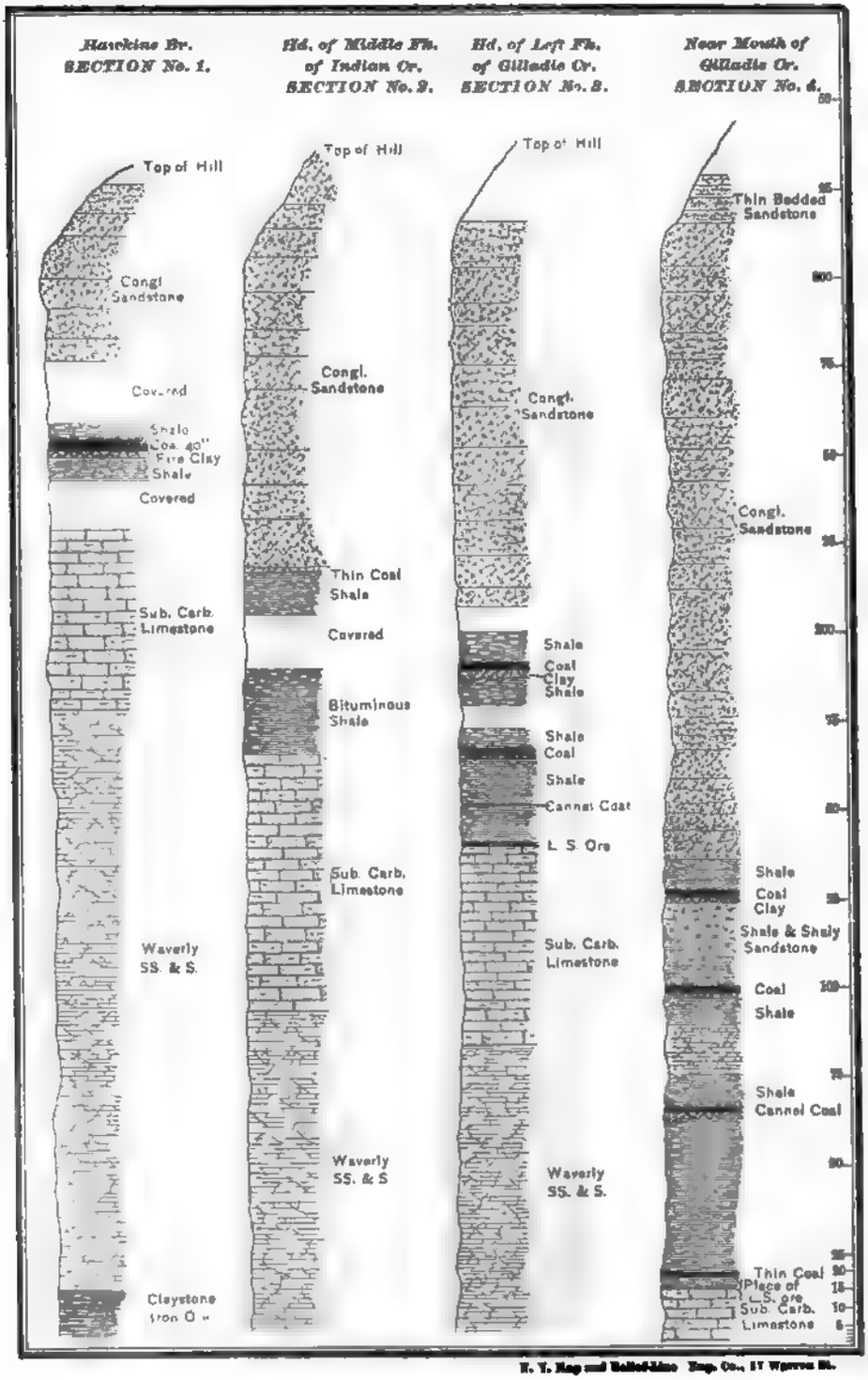
The timber of Menifee includes the following species, besides some others, which doubtless have been overlooked, no time having been at command for a special study of this subject. For a general view of the distribution of species, see report on the Timber Growth of Greenup, Carter, Boyd, and Lawrence Counties, vol. I, new series:

First in importance, both in value and in abundance, is the white oak (*Quercus alba, L.*) The black oak (*Q. tinctoria, Bartram*) is abundant on the hillsides. The red oak (*Q. rubra, L.*) has about the same range as the black oak, but is less abundant. The chestnut oak (*Q. prinus var. montacola*) is abundant along the ridges. In the report referred to above, this species was, by some mistake, given as *Q. castanea.* The pin oak, or perhaps the scarlet oak (not in season to determine species), generally present on the low spurs between the smaller streams. The Spanish and the laurel oak (*Q. falcata L.* and *Q. imbricaria, Mx.*) are found along the border of the county on Slate creek. The beech (*Fagus sylvatica, L.*) is abundant in the valleys generally. The sugar tree (*Acer saccharinum, Wang.*), the white or soft maple (*A. dasycarpum, Ehrh.*), and the red maple (*A. rubrum, L.*) are present—the first in considerable numbers, the last only met with here and there as a single tree. The tulip tree (*Liriodendron tulipifera, L.*), generally known as the yellow poplar, is abundant on the hillsides. The chestnut (*Castanea vesca, L.*) is found in great numbers towards the top of the hills. The hickories (*Carya tomentosa, Nutt., C. alba, Nutt.*, and *C. amara, Nutt.*) are well represented, and in the second growth, as on the hill west of Old Beaver Furnace, they often largely predominate, the first two species being most abundant. The black gum or gum tree (*Nyssa multiflora, Wang.*) is found

everywhere in small numbers. The white ash (*Fraxinus Americana, L.*) and the linden or linn, as it is sometimes called, are found in some of the valleys. The former is exceptionally abundant in the valley of Leatherwood Fork of Indian creek. The buckeye (*Æsculus glabra, Willd.*) is found in the larger valleys; the sycamore (*Platanus occidentalis, L.*) has about the same range. The elm (*Ulmus Americana, L.*) ranges from the creek bottoms well up on the hillsides. The black walnut and the white walnut grow in all the main valleys. The locust tree (*Robina pseudacacia, L.*) is seen occasionally on the hillsides. The cucumber tree (*Magnolia acuminata, Lam.*) is seen occasionally on the heads of streams, but rarely large enough to be valuable for lumber. The mulberry (*Morus rubra, L.*) is found along the base of the hills. The sassafras tree (*Sassafras officinale, Nees.*), the dogwood (*Cornus florida, L.*), and the sourwood (*Oxydendrum arborinum, D. C.*) are each of frequent occurrence. The redbud (*Circis canadensis, L.*) is occasionally, and the ironwood (*Ostrya virginica, L.*) is rarely, found on the hillsides. The hornbeam (*Carpinus Americana, Mx.*) and the willows are scattered along the streams. The holly (*Ilex opaca, Ait.*) is limited to the vicinity of the most precipitous cliffs. The pawpaw is abundant on the water-courses. The persimmon is less abundant.

Of the cone-bearing trees, the hemlock (*Abies Canadensis, Mx.*) and the yellow pine are the most abundant—the former on steep rocky surfaces near the streams, the latter along the ridges. The white pine (*Pinus strobus, L.*) is abundant in some parts of the Red River valley, but only a few trees of this species fall within the county line. A few red cedars (*Juniperus virginica, L.*) occur near the limestone cliffs or ledges.

The timber of Menifee, as of all the hilly counties, should be held in high estimation among those things that go to make up the natural wealth of the region.



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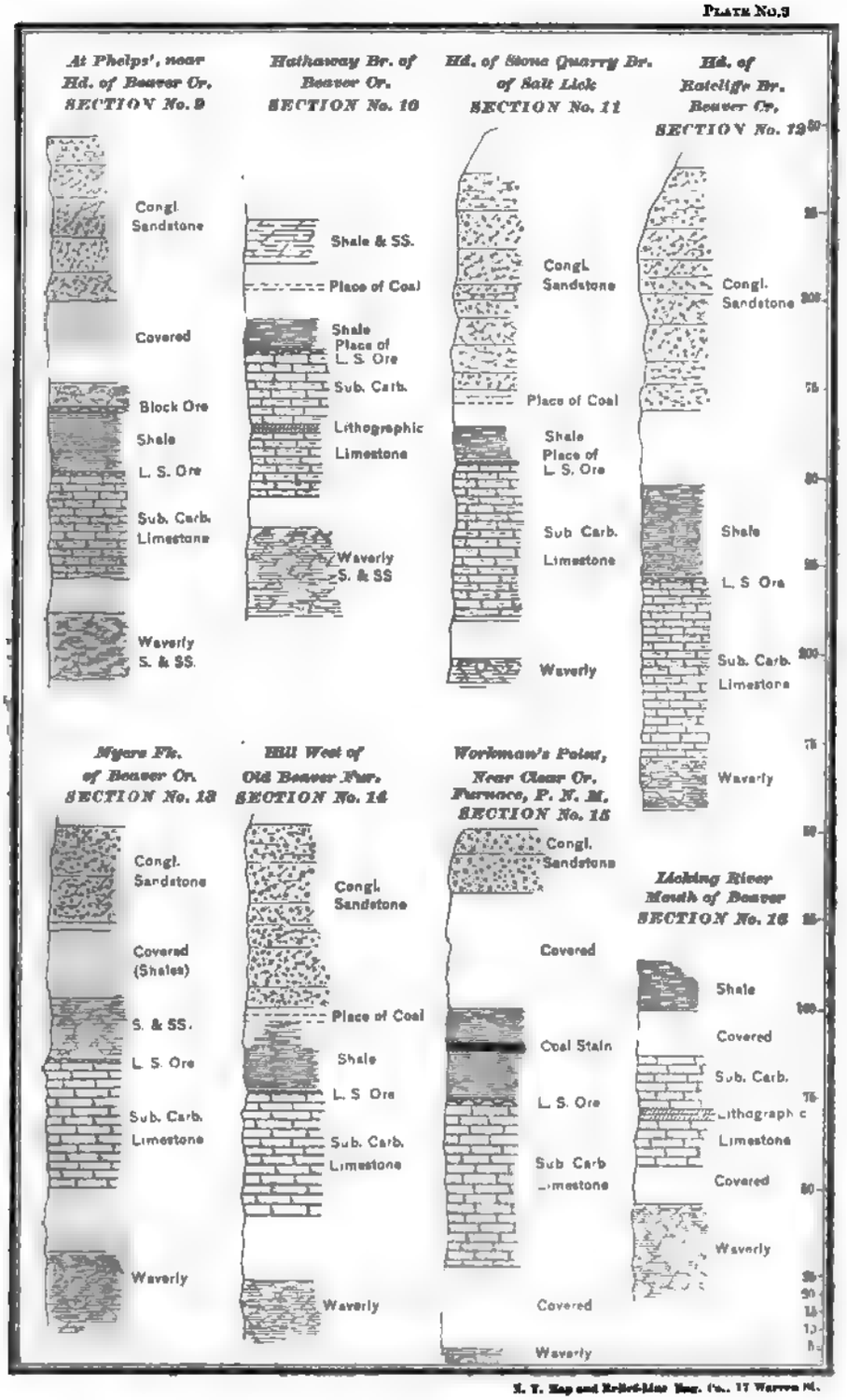

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GEOLOGICAL SURVEY OF KENTUCKY

N. S. SHALER, DIRECTOR.

REPORT

ON THE

IRON ORES & THE IRON MANUFACTURE

OF THE

KENTUCKY RED RIVER IRON REGION.

BY P. N. MOORE.

PART III. VOL. IV. SECOND SERIES.

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ON THE IRON ORES AND THE IRON MANUFACTURE OF THE KENTUCKY RED RIVER IRON REGION.

This region takes its name from the Red river, a branch of the Kentucky, upon which one of the earliest iron furnaces in the State of Kentucky, or in the West, was established.

The name Red River iron was first applied only to that made by those furnaces situated within the area drained by that stream; but, as the reputation of the iron in the markets of the West increased, the name was also applied to the product of furnaces beyond the neighborhood, but using the same ores, until the Red River Iron region grew to include territory drained by the Kentucky river itself, and its minor branches, the Red river, and the Licking, with some of its minor branches. It includes portions of Estill, Powell, Lee, Menifee, Bath, and Montgomery counties.

A more comprehensive definition of the region, as the term is used in this report, is to describe it as all that region lying between the Kentucky and Licking rivers, in which the Subcarboniferous or St. Louis limestone is found above the drainage. It is, therefore, an area about thirty-five miles long by ten miles wide, lying along the western border of the eastern Kentucky portion of the great Allegheny coal field. The name, as applied, is limited arbitrarily to the area between these rivers, because there are as yet no furnaces situated south of the Kentucky or north of the Licking river for a considerable distance, until the iron district of Carter county, of the Hanging Rock Iron region, is reached.

In discussing this region, there will be described—

I. The iron ores.

II. The iron manufacture.

I. THE IRON ORES.

The geological structure of a large portion of this region is described in detail in the report of Mr. Crandall upon the geology of Menifee county. The general type of geological structure, as there described, prevails over all this region. For the details as to special localities, the reader is referred to Mr. Crandall's report; but a few words of general description of the principal rock formations in this region will be given here, as being necessary to a correct understanding of the position of the ores to be described.

The rocks, which will be met with in almost all of the hills where the main ore of this region occurs, are, in a descending order, as follows: the Conglomerate sandstone and the underlying shales, with beds of coal, of the coal measures; the Sub-carboniferous or St. Louis limestone, and the Waverly sandstone of the Sub-carboniferous formation.

The Waverly, a fine-grained shaly sandstone, usually of a light olive-green tint, is the bed rock in which the streams flow, over the greater portion of the region under consideration, although toward the western border the Devonian black shale occupies this position, and the Waverly rises above the drainage. The Waverly has usually a thickness of about three hundred feet in this region.

Above the Waverly the Sub-carboniferous limestone is found, ranging from thirty or forty feet in thickness in the northern, to one hundred feet or more in the southern part of this region. Topographically this rock is not of great importance, except towards the southwest, where it is at its maximum thickness, and lies very near the top of the ridge, the Conglomerate and other overlying rock having been nearly all removed. Further to the east and northeast, where it lies nearer the drainage level, and the Conglomerate covers a large proportion of the surface, the limestone is thinner and more rarely exposed, being generally covered by the talus from the overlying Conglomerate.

Economically, however, the limestone is of great importance, as it is the rock upon which rests the ore of this region

which has given to it its reputation, and in itself it is valuable for building purposes, and furnishes a flux for the furnaces of the region.

The Conglomerate is the most conspicuous, and, topographically, the most important, of the members of the rock series of this region. It caps the most of the ridges, except on the extreme western border of this region, gradually descending towards the east and southeast, until it finally reaches the drainage level. It is a massive, pebbly sandstone, usually from one hundred to two hundred feet in thickness. Over part of this area it occurs in two members, with coal-bearing shales between. When this is the case, the upper Conglomerate is the most prominent, while the lower is usually not over thirty or forty feet thick, and occurs quite close down to the limestone, with sometimes not over ten feet of space between them.

The ores of this region belong to the class of earthy carbonates, or clay iron-stones and limonites, or hydrated oxides, resulting, with the exception of the ore of one deposit, which will be hereafter especially described, from the alteration and oxidation of the carbonates. They occur in stratified deposits at various geological horizons, not always forming connected strata, but still holding well-defined levels.

In the Waverly shales, toward the base of the series, there are numerous beds or layers of clay iron-stone kidneys, sometimes in considerable thickness. They are usually exposed along the banks and in the beds of the streams, where they have been left when the surrounding material has been washed away. Owing to their high specific gravity, the current has very little effect upon them, and they are thus concentrated in the beds of many of the streams in considerable quantities, so that, to the careless observer, they give the impression that there is a much larger quantity of the ore present in the hills than will be found on closer inspection. These ores have never, to the knowledge of the writer, been worked at any of the furnaces of this region. The reason of this, probably, is, that they are almost always found as hard blue carbonates, a

quality of ore which charcoal furnaces, the only kind as yet in this region, do not use if the limonite ores can possibly be obtained.

These ores are of such firm and close-grained structure that they yield to the oxidizing action of the air, and change to limonite very slowly, and with great difficulty. They are remarkable in this respect. Even when they are found in positions which show that they have been long exposed to the agencies which usually effect this change from carbonate to limonite, it is rare to find more than a thin coating of limonite on the surface of any specimen and along the lines of the weather cracks.

They are sufficiently rich in iron to be of value, and would doubtlessly be considerably used, were it not for the feature above noted. The deposits do not seem to be persistent over very large areas at the same level, but change position frequently. In addition to their irregularity, they commonly occur low down in the hills, where the slope is so steep that it would be impossible to bench for the ores to any depth; and they are usually too thin to pay for mining in any other way. The reason that they are not found near the tops of the hills is, that they lie towards the base of the series, and the Waverly does not extend far enough to the west to bring them to the top, where the slope over the ore would be gentle, and the thickness of overlying material slight, as these rocks soon disappear where the massive Conglomerate and limestone no longer protect them from erosion.

The thickness of these beds or layers of kidney ore ranges from four to eight inches. Were there furnaces in this region capable of using them, large quantities could be cheaply obtained and utilized, but it would not be judicious to rely upon them alone to supply any furnace; their proper use would be as a mixture to use with other ores.

THE LIMESTONE ORE.

The principal ore from which the iron has been manufactured, which has given to this region its reputation in the

markets of the country, is found resting upon the Sub-carboniferous or St. Louis limestone, and is known as the limestone ore. It is geologically the same ore as that already described in a previous report* as the "lower limestone" ore of Greenup and Carter counties.

The limonite of this bed, when at its best, is a heavy, dark red, friable ore, sometimes homogeneous and massive, and sometimes semi-concretionary. It often gives a red powder and streak, while containing its full proportion of combined water. The carbonate ore, from which the limonite is derived, is usually a dense, amorphous, close-grained ore, varying from light grey to dark brown in color.

The ore is found resting upon the surface of the limestone; not always in a regular layer or plate of uniform thickness, but in irregular "rolls," filling depressions in the surface of the limestone, between which the ore is often missing. These rolls are of much greater thickness than the average of the whole bed. They are often found several feet in thickness, while, when the ore occurs with anything like regularity, it is rare to find it averaging more than one foot. There is usually a considerable thickness of fine white shale and clay above the ore. This is a characteristic of the limestone ores in other parts of the State, which helps to distinguish them from other ores.

THEORY OF FORMATION.

In another report, already referred to, on the iron ores of Greenup, Boyd, and Carter counties, the theory of formation of these ores has been discussed, and to that report the reader is referred for a fuller statement than will be given here. It will be sufficient to state, here, the conclusions then reached, without repeating the different theories in regard to their formation, or the facts in favor of the conclusions below stated.

The carbonate or siderite is the original mineral of these ore beds, and from it the limonite, or the "red ore," as it is

*Report on the Iron Ores of Greenup, Boyd, and Carter counties, vol. I, part III, second series.

called, is derived by a process of oxidation and alteration through the agencies of the atmosphere and carbonated waters.

The depth to which the change from carbonate or siderite to limonite has been effected, varies with the character and thickness of the overlying material. Where this is thin, or where it is a porous sandstone, permeable to the atmosphere, the change will be found a long distance back from the outcrop, and sometimes entirely through the hill; but where a great thickness of impervious, dense rock overlies the ore, the limonite will be found only a short distance back from the outcrop, forming a narrow ring around the main body of carbonate ore, decreasing as the slope of the hill above it grows steeper. As the limonite ore is much the most valuable, owing to the fact that, in addition to its superior richness, it is more easily smelted and produces a better grade of iron, it will be seen that those deposits are of most value which are situated near the tops of the hills, where the ore has all been changed to limonite. The area covered by the ore bed, and the total quantity of the ore, when it is thus situated, is much less than when it lies lower down in the hills; but this is compensated by the superior quality of the ore.

The ore seems to have been formed by a segregation of the iron from the shales and clays above the limestone, subsequent to their deposition. Carbonated waters, percolating through these rocks, have taken the ferruginous material into solution in the form of the carbonate, carried it down and deposited it upon the face of the limestone, which, in its turn, was partially dissolved and carried away, thus producing the irregularities in its surface before referred to.

This theory of deposition, by segregation from the overlying rocks, accounts for the following characteristics of the ore, namely, the irregularity of thickness; the tendency to become suddenly calcareous, or to disappear altogether, giving place to a limestone: the comparative freedom from coarse silicious impurities, and the presence, above the ore, of the

thick beds of white clay, from which almost every trace of iron has been removed.

QUALITY OF THE ORE.

Unfortunately, at the time of the examination upon which this report is based, it was impossible to obtain as many thoroughly representative samples of the ore for analysis as were desired, owing to the fact that mining operations were being conducted at only one of the furnaces in this region. At the other furnaces the ore banks had nearly all fallen in soon after operations had been suspended, so that it was, in most cases, impossible to gain access to the ore in order to select average samples for analysis. The furnaces had also consumed almost entirely the stock of accumulated ore before going out of blast, so that it was impossible to obtain, at the stock piles, samples the location of which was known.

For this reason, the number of analyses given below is not nearly so large as desired, or as it would have been, had it been possible to get at the ore, in the banks, at many other places.

The same reason can be given why this report is not much fuller in details of measurements of the ore than it is. The furnace estates comprise but a very small proportion of the total area of this ore region. Except on these estates, no mining operations for ore have ever been conducted, and there is no means of knowing the exact thickness of the ore bed. The amount can only be estimated from the abundance, size, and persistency of the outcrop of the ore on the surface of the hill. This is only an imperfect method, and is subject to great inaccuracies; but it was the only one possible under the circumstances, as it is manifestly impracticable for the Geological Survey to undertake expensive explorations, which require digging. Neither time nor means was sufficient for such explorations.

The following analyses were made by Dr. Peter and Mr. Talbutt, from samples collected by the writer. They were all taken with a view to be as nearly average samples as pos-

sible; but they are not all equally so, for the reason that the amount of ore from which the sample was taken varied considerably. In some cases it was taken directly from the solid ore bed, while in others from the pile of ore lying on the bank:

	1	2	3	4	5	6	7	8	9
Iron peroxide	65.310	59.621	66.329	54.750	75.598	4.049	65.535	74.127	65.591
Iron carbonate	....	....	....	....	....	76.491	....	....	....
Alumina	11.947	12.370	12.532	14.517	1.971	2.014	2.798	3.542	5.762
Lime carbonate	.730	.500	a trace.	a trace.	.540	5.400	.450	.390	a trace.
Magnesia	.140	.144	.173	.047	.258	.514	1.073	.461	.248
Phosphoric acid	.825	.709	.709	.697	.601	.409	.537	.601	447
Sulphuric acid	a trace	a trace.	a trace.	a trace	a trace.	.267	a trace.	a trace.	a trace.
Combined water	11.000	10.400	9.580	8.600	11.730	*1.426	9.800	11.270	11.000
Silica and insoluble silicates	9.580	15.830	9.720	20.830	8.910	9.330	20.480	9.580	16.230
Total	99.532	99.574	99.043	99.441	99.608	100.000	100.673	99.971	99.278
Metallic iron	44.570	41.735	46.440	38.750	52.918	39.758	45.874	51.889	45.914
Phosphorus	.360	.309	.309	.304	.262	.178	.234	.262	.195
Sulphur	....	....	....	....	....	.107	....	....	....

*And loss.

No. 1 is from the Pergam bank, Bath Furnace, Clear creek, Bath county.

No. 2 is from a bank near the head of Clear creek, Bath Furnace.

No. 3 is from the Richardson bank, Bath Furnace, Clear creek.

No. 4 is from the head of Ratcliffe branch of Beaver creek, Menifee county.

No. 5 is limonite ore, from the Tubbs bank, Estill Furnace, Estill county.

No. 6 is the carbonate ore, from the same bank as No. 5.

No. 7 is from Logan ridge, Estill Furnace.

No. 8 is from the Luster drift, Thacker Ridge, near Fitchburg, Estill county.

No. 9 is from the Horse Ridge banks, Cottage Furnace, Estill county.

With the exception of No. 6, all the above analyses are of the limonite ore of this bed.

It is probable that they all show the ore to be a little richer in iron than it really proves to be on actual working in the furnace This is due partly to the personal bias of the sam-

pler, which always acts in favor of the ore, no matter how careful he is, and partly to the fact that the sample is taken cleaner and freer from adhering dirt and clay than it is as it comes to the furnace scales.

It is stated that the average yield of the ore at Bath Furnace is forty per cent. The average in the four samples—Nos. 1 to 4, inclusive—from ore used at this furnace, is 42.77 per cent. of iron. The localities represented by these samples, however, are those which furnish the best ore to the furnace; so that it seems probable these analyses do not represent the ore as much better than it really is. They are all from within a radius of three miles. They are remarkable for the large and uniform per centage of alumina—an amount not heretofore found in any other ores of the State. The phosphorus is also remarkably uniform, although not excessively high for ore of this character. The absence of all except a trace of sulphur, save in the one sample of carbonate ore, is an excellent feature in these ores, and one reason why they are so highly valued. Another point of excellence is the comparatively small amount of silicious matter. This averages less than in any other series of ores in the State, as yet analyzed. This, in addition to the varied character of the other impurities of the ore, no one of which predominates very greatly, renders it easy to smelt, and tends to the production of a high grade of iron, as the silicon is not reduced with the iron, but combines with the other impurities, and passes off into the slag. For the same reason, the ore does not require a large amount of limestone for flux.

Another good quality of these ores, when limonites, is, that they are of an open, porous structure, so that they are easily permeable to the reducing gases of the furnace, which, therefore, act upon them readily. The carbonates are of a closer, denser structure, and are not so easily reduced. It is probable that much of the difficulty in working these ores satisfactorily, is due more to this peculiarity of their structure, than to any excess of impurities, although it is commonly attributed to the presence of sulphur.

DISTRIBUTION OF THE ORES.

For reasons before stated, it is impossible to give accurate and detailed statements of the exact thickness and quantity of the ore for every locality in this region. The most that can be done is to give its thickness at a few prominent places where it has been mined, and some notes as to its apparent relative abundance at other localities.

As stated in a former report,* this ore occurs in abundance along the outcrop of the Sub-carboniferous limestone, from near the Ohio river, in Greenup county, to the southern part of Carter county. Around Olive Hill, where last examined in detail, the ore is present in abundance, and seems to occur with more than usual regularity. From here, south to the Licking river, there have been no detailed examinations made. The region is wholly undeveloped—no mining operations nor pick and shovel prospecting ever having been attempted as yet. To the south of this, although no detailed examinations have been made, the ore has been seen in considerable quantity towards the head of Big Sinking creek, a branch of Little Sandy river, on the very head waters of Tygert's creek, and also on Christy's Fork of Triplett creek, a branch of Licking river.

There is in this vicinity a large amount of ore which will be opened to the world by the completion of the Lexington and Big Sandy Railroad; but, until that is accomplished, must remain wholly undeveloped.

Between Christy's Fork of Triplett creek and the Licking river, nothing is as yet known as to the occurrence of the ore, but there is no reason to doubt its existence there.

South of Licking river the ore occurs in abundance, and has been largely mined. On Caney creek, a stream but a few miles in length, large quantities have been mined for the supply of the Caney Furnace, which was situated upon that stream. It has not been in operation for a number of years. As a consequence, all the ore banks have fallen in, and noth-

*On the Iron Ores of Greenup, Boyd, and Carter counties, part III, vol. I, second series.

ing could be learned in regard to the thickness of the deposits.

On Clear creek, in Bath county, the deposits of the ore are extensive, and of excellent quality. It has been largely mined for the supply of the Bath Furnace, formerly called the Clear Creek Furnace. Several analyses of ore from this vicinity are given in the table. The ore was seen, at a number of openings, from six to sixteen inches in thickness. It is reported to occur frequently in "rolls" or pockets of two to three feet thick or more; but these are usually of limited extent, and soon exhausted. The ore varies so in thickness that it is impossible to give any accurate estimate as to its average; but it is probable that it would be slightly under twelve inches. It is usually found here resting under about five feet of white clay. At this distance above the ore there is usually found in the clay a thin coal streak; but it has never, to the writer's knowledge, been followed far enough back into the hill to be found solid. It is probable that this is the stain of a coal which, in other places, has been opened and found to be about fifteen feet above the limestone. The distance from the ore to the base of the Conglomerate in this vicinity is about sixty feet.

All of the branches of Clear creek cut through ore territory, as do a portion of the branches of Salt Lick creek, the stream into which Clear creek flows. Some of the branches of Salt Lick creek on the west extend beyond the ore field, while the main stream runs so near its edge that only a comparatively small area of ore is found along it.

Although mining operations have been conducted on Caney and Clear creeks at various times for nearly forty years past, yet the supply of available ore is by no means exhausted. Neither of the furnaces has been in constant operation. Caney Furnace was discontinued in 1848, and Bath or Clear Creek Furnace was idle from 1857 or 1858 to 1873. The consumption of ore has, therefore, been comparatively small, and the great mass of available limonite ore is almost untouched. So far the supply available by benching has been

ample, and drifting for the ore has been resorted to at but few banks, and in these cases only where the ore was of more than usual thickness and regularity, so that it could be mined cheaply. The Pergam bank, on Clear creek, is an instance of this kind.

Beaver creek, from its head to its mouth, may be said to run through ore territory. It is a long stream, and drains an ore area of many square miles; but it is at present wholly undeveloped. The ore outcrops in the surface clays are abundant, and in quantities sufficient to indicate that the ore is present in its full average thickness. The Bath Furnace draws a part of its ore supply from the country drained by some of the lower branches of Beaver creek. Leatherwood creek furnishes the larger portion of this. There are numbers of old ore banks on the lower part of Beaver creek, where ore was probably dug for the old forges which formerly were in operation in this vicinity—one on Beaver creek, and one on Licking river below the mouth of Beaver These banks have all fallen in, so that it was impossible to ascertain anything as to the thickness of the ore.

Higher up on Beaver creek ore was formerly mined for the Old Beaver Furnace, which is situated near the mouth of Myers' branch; but this has been discontinued for over forty years, so that the ore banks are in the same condition as those just described. If all accounts be true, however, the ore in this vicinity is more than usually abundant and trustworthy. As the furnace was only in operation ten or twelve years, the total amount of ore consumed was comparatively small—not enough to seriously affect the value of the ore lands, as the great body of ore is comparatively untouched.

The country drained by the branches of Beaver creek on the south has been more thoroughly examined by Mr. Crandall than by the writer, and to his report the reader is referred for details.

From here up to the head of Beaver creek the ore appears in about its average abundance in the outcrop. No mining operations have ever been undertaken here, and, in conse-

quence, nothing in detail is known in regard to the ore. On the head waters of the south and southeastern branches of Slate creek the ore is well developed. It has been discovered at many places recently, since the thorough prospecting which that region has been undergoing in the search for coal. This region holds a large amount of ore as yet wholly untouched. The same is true of the area drained principally by Indian and Gilladie creeks, which flow into Red river from the north, and Chimneytop creek from the south. All this region, as well as that drained by the branches of Slate creek, has been examined more thoroughly by Mr. Crandall than by the writer, and to his report the reader is referred for fuller statements than are given here. Further down Red river the branches from the south cut through an extensive and valuable ore field. Middle Fork of Red river and Cat creek are the principal streams from the south. They head in the dividing ridge between the Red and Kentucky rivers, but a little to the east of where this ridge has been most productive of iron ore in the past. No ore of any consequence has been dug on these streams, except at the heads of some of the most westerly branches, on the Estill Furnace property; but, so far as surface indications are to be depended upon, the undeveloped regions promise to be equally as rich as the developed.

On Red river and its smaller branches considerable ore was formerly mined and carried down the river to the old Red River Forge and Furnace; but these have long since ceased operations, and the ore banks have not been opened since. These ore banks extended out to the west, on isolated knobs, to within a mile or two of the old forge.

The main dividing ridge between the Red and Kentucky rivers, where it is drained by Hardwick's creek, and the most westerly branches of Cat creek and Middle Fork on the north, and by Miller's and Cow creeks on the south, holds the ore in great abundance. This locality has been more extensively worked than any other of the region. It is on this ridge that the Estill and Cottage Furnaces are situated, and from it and its spurs they have drawn their ore supply—one of them, Es-

till Furnace, for the last forty-five years. Nos. 5, 6, 7, and 9, in the table of analyses, are from this ridge. These samples were taken from piles of ore lying at the banks, as it was impossible to reach the ore bed, mining having been discontinued about a year before the time of examination, and the banks, in consequence, having fallen in. At many places in this vicinity all the ore which is available by benching has been exhausted, and in future resort must be had to drifting. For the reason just stated, the face of the ore was seen at few places, so that accurate measurements of thickness cannot be given. It is stated to average somewhat less than one foot in thickness, though often occurring locally much thicker. Ore has been extensively mined along this ridge for a distance of six or eight miles, extending from two to four miles on the east of Estill Furnace to about the same distance west of Cottage Furnace, where the ore disappears, the limestone at this distance coming so near to the surface that the ore has been all removed. The heavy Conglomerate cliffs do not overlie the ore until in the vicinity of Estill Furnace. The lower and thinner Conglomerate overlies it around Cottage Furnace, the distance between being about twenty feet. The limit of mining operations on the east of Estill Furnace is not due to the disappearance of the ore, but to the fact that it cannot be profitably wagoned a greater distance than from the banks at present farthest removed from the furnace. There is an apparent abundance of ore for a long distance to the east along the ridge.

On the spurs of this ridge extending to the south, between the branches of Miller's creek, are situated the numerous ore banks which furnished the supply for the furnaces of the Red River Iron Company, at Fitchburg, on Miller's creek. The best known and most productive localities are called Thacker Ridge and Kobb Mountain. Thacker Ridge lies on the east side of the branch of Miller's creek upon which Fitchburg is situated, and about one mile from that village, while Kobb Mountain is about three miles below, on the same side. The ore banks or benches extend continuously along the outcrop

of the ore from one of these localities to the other. The ore has not only been benched for very deeply, but many drifts have also been run. It does not differ materially in quality or thickness from that on the main ridge at Estill Furnace. It was seen at a few places from eight to twelve inches in thickness; but many local "pockets" have been found in the drifts which reached three feet or more. Although some few minor spurs of Thacker Ridge have been nearly exhausted of their ore, yet there is in this vicinity a quantity of ore amply sufficient to meet all probable demands of the furnaces for a long time to come; for, in addition to the large amount yet remaining in the ridges east of Fitchburg, the ore in the ridge to the west is as yet intact, no mining of any consequence having been attempted there.

South and east of this vicinity, lying within the drainage of the main branches of Miller's creek, there is an extensive ore field, which is wholly undeveloped. It extends, on an average, from six to eight miles to the east. Ore will be found much further to the east; but beyond that distance the limestone is so near the drainage level that the outcrop line of the ore is limited, and the hills rise so steeply above that the amount available by benching is small. For the same reason, the amount of limonite, in proportion to the carbonate ore of the bed, is small, as the great thickness of overlying material prevents the alteration of the ore from carbonate to limonite.

The branches of Miller's creek draining this region head in the Conglomerate, and cut their channels in that rock and the shales below, for several miles, before they reach the limestone; so that the ore does not extend above the drainage level to the heads of these streams.

So far as it was possible to ascertain by merely surface examinations, this region seems to contain the ore in almost or quite as great abundance as the developed localities further north and west. It affords fine locations for the erection of new furnaces, as, in addition to the ore, the timber supply is good, the original unbroken forest still covering the greater part of the area.

Along the Kentucky river, on the north side, the ore is found at its proper level, in greater or less abundance, as far up as Contrary creek, a short distance above which the limestone passes beneath the drainage. On Contrary creek, however, and for some little distance below, surface indications do not promise much ore; but the circumstances are most unfavorable for its outcropping, as the top of the limestone is here almost to the drainage, and the hills rise steeply above. Further down the river, on the Willow Shoals branch, and the river hills above Old Landing, the ore is found in abundant outcrop and of excellent quality. On the Willow Shoals branch there are other ores lying in the shales above the limestone, of excellent quality, but apparently thin. Nothing is known of their horizontal extent.

South of the Kentucky river the limestone ore has not been mined, and its limits and distribution are almost unknown. Time did not admit of extending the examinations on this side to any distance back from the river. The geological features on this side are similar to those on the north, and there is no reason why the ore will not be found in as great abundance, when it comes to be sought for at its proper level. Outcrops of the ore were found on Buck, Ross, Station, Camp, and Doe creeks, and it is reported to occur abundantly on Sturgeon creek. As the limestone does not pass below drainage for some distance above the mouth of Sturgeon creek, it is not improbable this statement is correct, although the outcrops will probably be found more abundantly on the branches from the west, where the limestone is higher than on the main stream.

On all of the streams mentioned, the ore was found within a few miles of the river. In some places the outcrops were abundant, and at others scarce. There was no apparent difference in the quantity and distribution of the ore from a similar area on the north side of the river. The ore seems just as abundant, and of as good quality, as in the undeveloped localities on the other side.

Within the limits named, on this side of the river, there are many square miles of ore territory. The timber is almost unbroken, and exists close to the river in quantity sufficient to supply a number of blast furnaces for many years to come.

THE CLINTON ORE.

In Bath county, on the waters of Slate creek, about five miles south of Owingsville, there is a deposit of ore of a character different from any yet described. Neither geologically nor geographically does it strictly belong among the ores of the Red River Iron region; but as it is a somewhat isolated deposit, situated nearer to this region than any other, and is connected with it in certain economical relations, it will be described here.

The deposit is known as the Old Slate Furnace ore bank. It lies on top of two or three hills, about two hundred feet above Slate creek. It is associated with the yellow Silurian limestone of the Clinton period. It is, in fact, geologically, the same ore as that variously known as the Clinton, fossil, or dyestone ore, which is found along the "great valley" of the Allegheny Mountains from New York to Alabama, and is characteristic of the Clinton period at many other places.

The ore is a limonite, very oölitic and fossiliferous. It bears evidence of having been originally a hematite, similar to the Clinton ore as usually found; but it has lain so long exposed to the action of air and water, protected only by a thin covering of the soil, that it has absorbed water and been converted into limonite. It is a soft, earthy, inferior looking ore; but, as shown by analyses, is much richer than commonly supposed.

It is apparently a stratified deposit, but of comparatively limited extent horizontally. Its maximum thickness is stated at fifteen feet, which is said to be the thickness revealed by a test pit sunk some years since. On one end of the Block House hill the ore is exposed frequently from ten to twelve feet thick. The principal banks are known as the "Block House" bank and "Howard Hill."

The area covered by the ore on these two hills, and two or three smaller isolated knobs, as determined by the Survey of Mr. C. Schenk, Topographical Assistant of the Survey, is 1,943,870 square feet, or 46.9 acres. The average thickness of the ore over the whole deposit is difficult to estimate, as full exposures are rare, except on one end of the Block House bank. It would probably be considerably within the limit to place the average thickness of the whole deposit at ten feet; but for the sake of perfect safety in the following estimate of the quantity of ore in this deposit, it will be placed at eight feet. The determination of the specific gravity of two samples by Mr. Talbutt gave respectively 3.405 and 3.47. With a specific gravity of 3.4, an average thickness of eight feet, and an area of 46.9 acres, the total amount of ore will be 1,475,259 gross tons. With an average thickness of ten feet the amount will be 1,844,073 gross tons.

It is believed that the above estimate is far within the limits of the quantity actually present, as a part of the deposit is nearly twice as thick as the estimated average, and there are few, if any, places where the ore seems to be below the estimate. This ore differs very materially from the Clinton, or dyestone ore, as usually found in other States, in that it seems to be of limited horizontal range. The elevations in the vicinity, besides the hills just named, which are high enough to hold the ore if it were widely extended, are few, and in them, if the ore be present at all, it is so thin that it gives scarcely any outcrop on the surface. Further east, where the dip has brought the rocks down, the ore seems to be wanting. The place of the ore is apparently about forty feet below the top of the yellow Silurian limestone.

At one or two localities within a few miles of these banks, an ore has been observed at the junction of the Devonian shale and the underlying limestone. This ore differs widely in its structure and composition from the Clinton ore. It is a very silicious, porous limonite, and apparently is of recent formation, deposited by the waters of chalybeate springs. At one

of the places where this ore was found the spring is still flowing.

The following is an analysis of a sample of this variety of ore, from a hill called Pilot Knob, near the line of the Lexington and Big Sandy Railroad, in Bath county:

ANALYSIS BY DR. PETER AND MR. TALBUTT.

Iron peroxide	47.321
Alumina	5.418
Lime carbonate	.690
Magnesia	.079
Phosphoric acid	.161
Sulphuric acid	.376
Silica and insoluble silicates	33.330
Combined water	12.050
Total	99.425
Metallic iron	33.125
Phosphorus	.070
Sulphur	.150
Silica	27.600

At Daniel Blevins', a few miles east of this place, an ore was found occupying a similar position, but of somewhat better quality.

QUALITY OF THE CLINTON ORE.

The chemical composition of the ore from the Old Slate Furnace banks is shown by the following analyses by Dr. Peter and Mr. Talbutt, from samples selected by the writer. The samples were intended to be as fairly representative as possible:

	1	2	3
Iron peroxide	76.077	69.728	70.060
Alumina	2.592	8.642	4.540
Manganese	.430	.....	.....
Lime carbonate	.130	.170	.040
Magnesia	.281	.045	.021
Phosphoric acid	.731	1.154	1.620
Sulphuric acid	.030	.134	.031
Silica and insoluble silicates	8.180	7.930	11.530
Combined water	12.300	12.650	12.300
Total	100.751	100.453	100.142
Metallic iron	53.254	48.809	49.042
Phosphorus	.319	.504	.707
Sulphur	.011	.053	.012

No. 1 is from the Block House hill; sample from all parts of the ore exposed.

No. 2 is from same locality; sample from the upper part of bed.

No. 3 is from the Howard hill.

It will be seen by the above analyses that the ore is much richer in iron than is generally supposed. The per centage of phosphorus is also large, as was indicated by the character of the iron made from the ore.

The country in the vicinity of the ore is pretty generally cleared of its timber, so that it is doubtful if this ore will be again used in this vicinity for the manufacture of charcoal iron; but it will in the future be largely shipped to furnaces using stone-coal, in the Hanging Rock region and other localities, where it will be used to mix with the coal-measure ores. The ore is but a short distance from the located line of the Lexington and Big Sandy Railroad, and would furnish a large amount of freight to that road upon its completion. It will prove valuable to mix with the limestone ore of the Red River region, and will be extensively used for that purpose when some means of cheap transportation can be had.

II. THE IRON MANUFACTURE.

The iron manufacture of this region is the oldest in the State of Kentucky, if not in the West.

As yet it has been confined to the production of cold-blast charcoal iron, which is used mostly for the manufacture of car-wheels, for which purpose it is unsurpassed by any iron in the country. It is of great strength, and at the same time chills readily. It has commanded a market all through the West, where it ranks with the best known and most celebrated brands of car-wheel iron in the country.

The first furnace in Kentucky was situated on Slate creek, in Bath county, and was called the Slate Furnace. It does not properly belong to the Red River Iron region, as it used different ore, produced a different grade of iron, and was located some distance from the other furnaces; but as it was the pioneer furnace in the State, and the only one in this vicinity, it will be described here.

According to one authority, it was built in 1791 by Thos. Dye Owings; according to another, it was built in the same year by Jno. C. Owings. It continued in operation until 1838. It used the Clinton ore from the already described banks, which were two miles south of the furnace. The blast machinery was driven by water-power, which was often insufficient to give sufficient blast to keep the furnace working regularly. There were two forges in the vicinity which made bar iron from the pig iron of the furnace.

Mr. Joshua Ewing, who was in charge of the furnace for the last ten years of its operation, states that its production was about three tons per day, using nearly or quite three tons of ore to the ton of iron.

The working of the furnace was very wasteful, as is shown by the character of the slag produced, and the fact that, so large an amount of iron was lost in the slag as scrap, that after the furnace ceased operations, the slag heap was worked over, the slag broken up, and a large amount of scrap iron obtained from it. This excessive waste of iron accounts for the difference between the yield as reported and the per centage of iron in the ore as shown by the analyses. The iron made at this furnace had a poor reputation as regards strength, but was very hard. This was due to the large

amount of phosphorus which it contained, as is shown by the following analysis of a piece of scrap iron from Slate Furnace, by Dr. Peter and Mr. Talbutt:

Iron	92.056
Graphitic carbon	3.640
Combined carbon	.310
Silicon	1.760
Slag	.100
Calcium	.116
Phosphorus	1.080
Sulphur	.218
Total	99.280

This iron is not of as good quality as that made from the limestone ore.

The next furnace established, and the first in the Red River region proper, was on Red river, in the large bend above the mouth of Hardwick's creek, in Estill county. It was built in 1806 or 1808 by Wm. Smith. There was also, at the same place, a forge running four bloomery fires, which was built a year or two previous to the furnace. The supply of ore was obtained from the hills on both sides of the river, some distance above the furnace, and boated down the river in flat-boats to the dam just above the furnace. This dam backed the water sufficiently to render the river navigable for small boats. It also furnished the water-power to drive the blast machinery of the furnace.

This furnace was in operation until about 1830. There was subsequently a rolling-mill erected at this same place, which continued in operation till about 1860, when it was removed, owing to the excessive cost of coal, which was brought down the Kentucky river and wagoned across.

It is stated that the furnace stack was first constructed of the Devonian black shale, which is the prevailing rock in the vicinity. This shale contains a considerable amount of bituminous matter, which, when the furnace became heated, took fire and burned all through the stack, with the result that the rock was so softened and cracked that the furnace had to be rebuilt with more solid material.

The next furnace erected was Beaver Furnace, on Beaver creek, Menifee county. It was built in 1819, by John T. Mason and four others, whose names could not be clearly deciphered from the inscription on the old stack.

This furnace, like the other two, was driven by water-power. There were two forges near, one on Beaver creek below the furnace, and one on Licking river below the mouth of Beaver creek.

The furnace continued in operation until about 1830. It used the limestone ore from the vicinity.

These three furnaces were built and running several years before the erection of the first furnace in the Hanging Rock iron region, which was built in 1822. They, as well as Caney Furnace, on Caney creek, which was built in 1838, by Mr. Joshua Ewing, and went out of blast in 1848, have all been abandoned, from one cause or another; usually either excessive cost of transportation or exhaustion of timber supply.

The active furnaces of this region are five; they are as follows:

Name of Furnace.	When built.
Estill	1830.
Bath	1839.
Cottage	1856.
Red river, two stacks	1869.

Bath Furnace, as already stated, is situated on Clear creek, in Bath county. Estill and Cottage Furnaces are on the ridge between the waters of the Red and Kentucky rivers, while the two stacks of the Red River Company are situated on Miller's creek, about six miles from the Kentucky river. All of these are in Estill county. The machinery of all these is driven by steam.

With the exception of the two furnaces of the Red River Iron Company, which will be described hereafter, these furnaces are all of the old type, with heavy sandstone stacks, in the form of a truncated pyramid.

The principal internal dimensions of these furnaces are shown by the following table:

DIMENSIONS OF BLAST FURNACES IN THE RED RIVER IRON REGION.

	Bath.	Cottage.	Estill.	Red River, 2 stacks.
Height	40′	38′	34′	50
Diameter of bosh	10′ 6″	10′ 6″	10′	12′ 6″
Batter or slope of bosh	58°	55°	55°	55°
Diameter of throat	3′ 6″	3′ 2″	4′	7′
Height of hearth	6′	6′	6′	6′ 6″
Diameter at top of hearth	3′ 8″	3′ 4″	3′ 2″	4′ 4″
Diameter at bottom of hearth	3′ 3″	2′ 8″	2′ 6″	3′ 9″
Number of tuyeres	2	2	1	3′
Diameter of tuyeres	3½″	3½″	3″	4″
Height of tuyere above bottom of hearth	2′ 7″	2′ 8″	2′ 6″	3′ 6″
Number of boilers	2	2	2	4
Diameter of boilers	2′ 10″	3′	3′	3′
Length of boilers	50′	46′	45′	45′
Number of blast cylinders	2	2	1	1
Diameter of blast cylinders	2′ 10″	3′ 4″	3′ 4″	5′
Stroke of blast cylinders	6′	one 6′ / one 5′	5′	4′
Diameter of steam cylinder	1′ 2″	1′ 4½″	1′ 4″	2′
Stroke of steam cylinder	6′	6′	5	4′

These furnaces all use the limestone ore, working with cold-blast for the production of a car-wheel iron. The Red River Furnaces are the only ones which have a hot-blast oven connected with them, and this has not been used since the first year or two of the furnace operations.

The dimensions and arrangement of the two stacks of the Red River Iron Company, at Fitchburg, on Miller's creek, are shown by the accompanying plate. They represent the first attempt at improved furnace construction in this region. They are twin stacks built in a solid rectangular mass of masonry, forty by sixty feet base, and fifty feet high. They worked with closed tops, originally with the bell and hopper apparatus; but this was finally removed, and a thimble-charging apparatus substituted. The hot-blast oven is on top of the stack. The gases are carried down twenty-two feet, through a gas main twenty-six by thirty-six inches in cross-section, to the boilers, of which there are eight, in four nests of two each.

The engines are modern, vertical, direct acting, with steam cylinder twenty-four inches diameter and four feet stroke; blast cylinder five feet diameter by four feet stroke. Everything in connection with the furnaces is constructed in the most thorough and substantial manner. The cost of the furnaces alone, without machinery, was over one hundred thousand dollars, while the cost of the machinery and fittings brought the total cost of the two stacks to nearly one hundred and sixty thousand dollars.

The metallurgical success of these furnaces has been all that was expected; the iron produced was of the very best quality, and commanded the highest prices, and the furnaces produced a large yield on a moderate consumption of charcoal. One stack has made as much as 480 tons of cold-blast iron in one month, on a consumption of 166 bushels of charcoal to the ton of iron; and during one week it made 128½ tons, using only 155 bushels of charcoal per ton. This, however, was exceptional working. The average consumption of charcoal was somewhat greater, and the production of iron less. The following table shows the average yield of the roasted ore, the consumption of charcoal per ton of iron, and the number of years during which the furnaces were in operation, from which these results were averaged. This table includes the two stacks which were respectively named Chandler and Blackstone, and also Estill Furnace, which is the property of the same company:

RED RIVER IRON COMPANY'S FURNACES.

Name of Furnace.	No. years from which averaged.	Average yield of roasted ore, per cent.	Average consumption of charcoal per ton of iron, bushels.
Chandler	4	44.2	231
Blackstone	5	45.1	204
Estill	5	46.4	215

It was impossible to obtain the figures for the yield of the raw ore with any accuracy. It is stated, however, by those connected with the furnace, to be thirty-three and one third per cent. One series of figures, obtained with regard to the

yield from the raw ore at Estill Furnace, gave the average for five years as 33.03 per cent.; but there was some obscurity in regard to some of the items which cast a shade of doubt over their accuracy. The returns for the yield of roasted ore are probably accurate, as they were taken from the daily blast report book.

It is to be regretted that it was impossible to obtain similar returns from the other furnaces of this region. The average yield of the roasted ore at Bath Furnace, for one period of sixteen weeks, was 51.7 per cent. No returns of charcoal consumption were obtained from this furnace.

None of the furnaces of this region are at present in operation, or have been since 1874, with the exception of Bath Furnace, which made a short campaign in 1875, during which less than fifty tons of iron were made.

This is due to the extremely depressed condition of the iron trade all over the country, the prices of pig iron ruling so low at present that it cannot be manufactured in this region and brought into market at a profit. This is owing more to the excessive cost of transportation to market than to the original cost of the iron at the furnaces. Iron can be produced at these furnaces for much less than at many other localities which are nearer to market, as ore, charcoal, and labor are all cheap; but the facilities for transportation are so poor, that it costs from seven to ten dollars per ton to carry the iron from the furnace to market at Louisville or Cincinnati. This tax is so great that, at present prices, it either entirely consumes the profits, or leaves the margin so small that it is not worth the risk.

The furnaces of the Red River Company, on Miller's creek, shipped their iron in flat-boats down the Kentucky river at time of high water, while the other furnaces usually hauled their iron to the railroad, in every case a distance of over twenty miles. Were there railroad or slack-water transportation within a few miles of each furnace, it would be profitable to make iron in this region, even at the present extremely low prices; but the necessity for wagoning it such great dis-

tances, or of awaiting the uncertain rises of the Kentucky river, and the danger of navigation when the rises come, render the cost of transportation entirely too great.

The construction of any of the projected railroads through this part of Eastern Kentucky, or the extension of the system of slack-water navigation on the Kentucky river to the mouth of the Three Forks, will give the desired facilities to a large part of this region, and be followed by the erection of new furnaces where heretofore the ores have lain undeveloped, owing to the difficulty and cost of getting the iron to market.

As a commercial enterprise, the furnaces of the Red River Iron Company have not been successful. From a metallurgical stand-point, the furnaces have been all that could be expected; but the property of which they form a part, and in which they are the chief producing apparatus, has not been profitable to its owners.

After an investment of about one and a half millions of dollars in lands, furnaces, buildings, dwelling-houses, tram-ways, roads, and other improvements, the company has failed to pay the interest on its bonded debt, and the property has passed into other hands, leaving a clear loss of over a million of dollars to the original stockholders.

These stockholders were mostly capitalists from outside the State, and the failure of an enterprise in which they had invested so largely, and which had been so liberally established, cannot fail to greatly injure the reputation of this region as an iron-producing district, and seriously retard its development in the future, by preventing the investment of capital from abroad, as it will inevitably be charged to the incapacity of the region to sustain an extensive iron industry, unless it can be shown that other causes should be charged with the failure.

That this is the case there can be little doubt. In the first place, it can be said that the furnaces were not adapted to the region, nor for the purpose of making charcoal iron. There was no difficulty, so far as the mere working of the furnace was concerned; but the capital mistake was in erecting two

such large and unnecessarily expensive furnaces, away from any line of transportation, with the expectation that they would both be supplied with ore and charcoal from the immediate vicinity. The furnaces each require, to keep them in operation, about double the amounts of ore and charcoal that the older and smaller furnaces use. The large furnaces will each produce, when working anything like full time, from three thousand to four thousand tons of iron per annum. To make this amount of iron will annually strip about four hundred acres of land of its timber, or eight hundred acres for the two furnaces. At this rate of consumption, the land around the furnaces would be cleared so rapidly that, in a few years, the limit of economical haulage of charcoal would be reached. The same would occur with the ore supply. The ore deposits of this region are of such a character that, so long as they are used by charcoal furnaces, which work exclusively the limonite, which is found only near the outcrop, a very large area of the ore bed will be required to supply the demands of a furnace. Only a comparatively small amount of ore is usually obtained at one locality; so that, when a large production is required, the exhaustion of the limonite in any given region is rapid; the workings are removed farther and farther from the furnace, and the cost of hauling the ore increases proportionately. Where the ore is obtained by drifting, instead of benching, this does not take place so rapidly; but, as a general rule, not a great deal of limonite is obtainable in this way, as the ore changes to carbonate on following it under ground, where the overlying rock is thick and impervious. There are many localities near the western edge of this ore field where the thickness of rock over the ore is slight, and the whole ore bed is changed to limonite; but, where this is the case, the total area of the ore is small, as it lies so near the summit of the hill.

The style of furnace adapted to the economic necessities of this region, is either a small cheap furnace, which can use all the ore and timber within easy hauling distance, and then be abandoned after twenty or thirty years without great loss,

or a more expensive, larger furnace, intended to be permanent, located upon some line of transportation, either railroad or river, by which supplies of ore and fuel can be cheaply brought to it from a distance, after that within hauling distance has been exhausted.

With a reasonable cost for transportation of iron to market, a large number of furnaces of either or both of these classes can be sustained in this region, and will produce iron so cheaply that it can be manufactured at a profit in almost any probable state of the market. These conditions apply to the charcoal iron manufacture. With reference to the manufacture of iron with stone-coal or coke, an industry which has not been attempted here as yet, but which is destined at some not far future day to become important, it may be said that the location of furnaces for this purpose, on some line of transportation, is absolutely essential, as the coal will have to be brought from further back in the eastern coal field; for, with a few exceptions, the Sub-conglomerate coals are not at their best development where the ore is found at its best. An additional reason is, that stone-coal iron, being a lower-priced product, will not bear the expense of transportation that charcoal iron can.

The furnaces of the Red River Iron Company are fitted to none of the conditions best adapted to economical and profitable working in this region. They are large, expensively built furnaces, furnished in the most complete and substantial manner, and everything about them showing that they were built to be permanent. They are, however, located six miles from the Kentucky river, to which the iron had to be hauled for shipment. They are, therefore, dependent upon the immediate vicinity for their supply of ore and fuel. Experience has proved that it is inadequate to supply, at reasonable rates, the amount required to keep both furnaces in full operation for the most of the time. The two furnaces require, to keep them in constant operation, about four times the amount of ore and fuel which any one of the older furnaces of this region use.

The records of the two furnaces show that, with the exception of the year 1871, which was the first year after both were fairly started, and when they together produced between seven and eight thousand tons of iron, they have never both been worked to anything approaching their full capacity; and this, too, during part of the time when iron commanded the highest price it has reached for years, and when, therefore, every inducement was offered managers to urge the production of their furnaces to the utmost limit. This proves the original statement, that, to supply two such large furnaces at profitable rates, is beyond the capacity of the region immediately surrounding and within easy hauling distance.

In addition to the mistake in the location and size of the furnaces, they were unnecessarily expensive. The same may be said of all the improvements made by the company. The number and style of buildings, and the investments for roads, tram-ways, &c., were somewhat extravagant. The buildings of one sort and another cost considerably over two hundred thousand dollars, while the cost of roads, tram-ways, inclines, etc., was nearly one hundred thousand. All of these items, added probably to some considerable extravagancies, or at least the lack of economy in the management, combined to make the total investment of capital in the enterprise much greater than could reasonably be expected to pay a good interest, under the most favorable circumstances.

As a further proof of the above statements in regard to these furnaces, it may be stated that Estill Furnace, which, with all its buildings and improvements, cost not more than ten or fifteen per cent. of the total cost of the large furnaces and their improvements, produced, in the five years from 1870 to 1874, inclusive, nearly one half as much iron as was made by the two large furnaces, when, had they been worked up to their capacity, they could readily have made four times as much as the smaller furnace, with its imperfect machinery.

When improved transportation facilities are afforded this region, so that iron can be shipped to market at a reasonable price, these furnaces will be profitably operated, for a portion

of the year at least, with ore and charcoal obtained from the immediate vicinity; but they will be best developed by a railroad which shall bring to them ore and fuel from a distance.

This whole region has a great future before it as an iron manufacturing district. It is capable of sustaining many times the present number of furnaces; but its development must depend upon, and be determined by, new lines of transportation. Until means of transportation are improved, it is useless to look for any great development. The character of the ore deposits must also be considered in constructing furnaces in this region, and only furnaces adapted to them be erected. The experience of the Red River Iron Company proves conclusively that this pattern of furnace is not adapted to this region, unless the furnaces be situated on some line of transportation where ore and coal can be brought from a distance.

QUALITY OF IRON.

The following analyses show the chemical composition of a number of samples of iron from this region:

ANALYSES OF COLD-BLAST CHARCOAL PIG IRONS FROM THE RED RIVER IRON REGION, BY DR. R. PETER AND MR. J. H. TALBUTT.

	No. 1 Cottage.	No. 1 Estill.	No. 1 Red River	No. 3 Red River	No. 5 Red River	No. 1 Bath.	No. 2 Bath.	No. 3 Bath.	No. 4 Bath.
Iron	93.106	92.582	94.174	93.728	93.963	92.631	91.924	93.472	93.004
Graphitic carbon	3.860	3.500	3.340	3.520	2.000	3.840	3.440	3.100	2.700
Combined carbon	.590	1.200	1.110	.780	2.550	.710	1.060	1.510	1.410
Silicon	.914	.960	.447	1.202	.363	1.520	1.319	.652	1.007
Slag	.160	.360	.360	.360	.320	.100	.260	1.600	.260
Phosphorus	.527	.444	.402	.290	.338	.363	.220	.290	.262
Sulphur	.011	.066	.182	.081	.104	.278	.107	.121	.172
Total	99.168	99.112	100.015	99.961	99.638	100.180	98.330	100.745	98.815

Some of the above analyses were more complete than as given here. For the complete analyses, see the report of Dr. Peter.

The excellent quality of this iron is due to the comparatively small per centages of phosphorus and silicon. A comparison of these analyses with those of Hanging Rock hot-blast pig irons, published in volume I, second series, Kentucky Geological Reports, shows a marked difference in the

per centages of these ingredients in favor of the Red River irons. When the Red River ores come to be worked with hot-blast, it is probable that the per centage of silicon will be increased; but the phosphorus will remain about the same.

PRODUCTION OF IRON.

The following table shows the production of iron in this region for the years 1870 to 1874, inclusive. In 1875, there was no iron made at any of the furnaces, with the exception of one lot of forty-eight tons at Bath Furnace.

These figures were obtained from the furnace books for all the furnaces, except Cottage. The returns for that furnace are probably accurate, as they were obtained from the former proprietors:

Name of Furnace.	1870.	1871.	1872.	1873.	1874.
Bath	not in blast	not in blast	not in blast	795	1339
Cottage	*1000	1850	1900	1950	not in blast
Red River Iron Company's Furnaces. Estill	1167	1880	1967	1375	388
Red River Iron Company's Furnaces. Chandler	2109	3855	2564	613	not in blast
Red River Iron Company's Furnaces. Blackstone	772	3529	289	1057	1284
Total	5050	11114	6720	5790	3011

*Estimated.

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217 & 218

GEOLOGICAL SURVEY OF KENTUCKY.

N. S. SHALER, DIRECTOR.

REPORT ON

A GEOLOGICAL RECONNOISSANCE

OF THE REGION ADJACENT TO THE

KENTUCKY & VIRGINIA STATE LINE,

FROM CUMBERLAND GAP TO THE CHATTERAWHA OR BIG SANDY RIVER.

BY P. N. MOORE.

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REPORT OF A GEOLOGICAL RECONNOISSANCE OF THE REGION ADJACENT TO THE KENTUCKY AND VIRGINIA STATE LINE, FROM CUMBERLAND GAP TO THE CHATTERAWHA OR BIG SANDY RIVER.

The State line between Kentucky and Virginia, beginning at a point a few hundred yards from Cumberland Gap, where the three States of Kentucky, Tennessee, and Virginia corner, follows the crest of the Cumberland Mountain, which is also the dividing ridge between the waters of the Cumberland and Tennessee rivers, for about thirty-five to forty miles,* to the head of Crank's creek, a branch of Martin's Fork of Cumberland river. It here leaves the Cumberland Mountain, which turns more to the east; and follows the crest of the Little Black Mountains, which now form the dividing ridge between the just mentioned rivers, having on one side the head branches of Martin's and Clover Forks of the Cumberland, and on the other those of the North Fork of Powell's river.

The State line follows the crest of the Little Black Mountains to their junction with the Big Black Mountains, at the head of Clover Fork of Cumberland, when it turns to the top of the Big Black Mountains, which it follows to the head of Poor Fork of Cumberland river, where the Big Black Mountains abut against the Pine Mountain. The Big Black Mountains lie partly between the Clover and Poor Forks of Cumberland, and partly between the Poor Fork of Cumberland and the North Fork of Powell's river.

At the head of Poor Fork the State line crosses to Pine Mountain, which is here sometimes called the Laurel and

*There is no accurate map of this region, and, in consequence, the distances given are only approximations, as nearly accurate as could be obtained.

sometimes the Cumberland Mountain, and follows its crest to the end of the mountain, at Russel Fork of Chatterawha or Big Sandy river, a distance of about thirty-five miles or more.

It will be seen, therefore, that the discussion of the geology of the region adjacent to the State line involves the examination and description of three mountain ranges—the Cumberland, Black, and Pine.

THE CUMBERLAND MOUNTAIN.

The Cumberland Mountain, along which the Kentucky-Virginia State line runs for such a distance, is identical with the mountain of the same name in Tennessee, which forms for some distance the upturned rim or edge of the "Cumberland Table Land" of Prof. Safford's Tennessee Geological Report.

It is a long narrow ridge, running in an east northeast and west southwest direction, and varying in height from nine hundred to two thousand feet above the adjoining valley. The crest line of the mountain does not follow a straight line; there are many minor curves and changes in direction, but it preserves a general course about as stated.

The mountain is formed of the tilted rocks of the Carboniferous, Sub-carboniferous, Devonian, and Silurian periods, dipping to the northwest at angles from fifteen to ninety degrees, varying for almost every separate mile of its length. The direction of the dip is also subject to local changes, which are the cause of the changes in the course of the crest line of the mountain. The crest line represents approximately the strike of the rocks, for the mountain recedes or wears away along a line at right-angles to the dip. A change, therefore, in the direction of the dip, results in a change in the direction of the crest line.

The determining rock which forms the crest of the mountain, and gives character to its topography, is always one of the Conglomerate sandstones of the lower coal measures.

Of these sandstones, there are a number, from seventy-five to three hundred feet in thickness, separated by shales or shaly sandstones, carrying beds of coal. These Conglomerates are

roughly divided into two series, an upper and lower. This division, at places, is well marked; at others, it cannot be traced. There is a considerable thickness of shale or shaly sandstone between the lowest of these Conglomerates, and the underlying Sub-carboniferous limestone. These Conglomerates represent the single sandstone, which near the Ohio river lies at the base of the coal measures. This increases in thickness toward the south, and separates into several members, while the space between, filled with shale and shaly sandstone, grows thicker in proportion to the increase in the thickness of the Conglomerates, and contains a number of coals.

The total thickness of these Conglomerates and the interconglomerate beds, all of which may be embraced under the term Conglomerate series, is in the neighborhood of two thousand feet. These Conglomerates can no longer, therefore, be strictly said to mark the base of the coal measures.

The crest of the ridge is formed sometimes by the upper and sometimes by the lower Conglomerates, depending largely on the degree at which the rocks dip. Where the dip is gentle, the upper Conglomerates come to the top, and the mountain attains its maximum height; but where the dip becomes steep, these retreat back on the northwest or Kentucky slope, and the lower come to the crest, the mountain decreasing at the same time until it is at its minimum, when the dip of the rocks is steepest.

These Conglomerates are usually quite pebbly, massive, cliff-forming sandstones, yielding to erosion slowly, and, in consequence, forming by far the most conspicuous feature in the topography of the mountain. Fine exposures, in the shape of splendid cliffs, from one hundred to four hundred feet high, are seen all along the mountain face. The shales between and below the Conglomerates are much more rarely exposed, as they are usually covered by the talus from the overlying sandstones. In fact, no complete exposure of these beds has yet been obtained in this region, and it is unknown, at this time, how many and what thickness of coal seams they contain. The place of one coal is well ascertained; but, as

it is nowhere opened for mining purposes, its thickness and quality are as yet unknown. The "stain" of other coals has been seen occasionally between the Conglomerates, but their exact positions are not yet determined.

The next most prominent member of the rock series of the Cumberland Mountain, after the Conglomerate series, is the Sub-carboniferous or St. Louis limestone. This limestone is from four hundred to five hundred feet thick. It is seen at many prominent outcrops on the mountain, the most notable of which is the cliff at the "Pinnacle," Cumberland Gap. It is by no means so often exposed as the Conglomerate, for the reason that, like the shales, it is covered by the talus, or the broken weathered fragments from that sandstone. Its place can, however, usually be determined by the bench which it forms in the hill slope.

Below the limestone, a fine-grained, greenish shaly sandstone, about one hundred and fifty feet in thickness, occurs. It is the sandstone variously known as the Knob stone, in the old series Kentucky Geological Reports, the Silicious, of Prof. Safford's Tennessee Geological Report, and the Waverly, of the Ohio Reports, which latter name has been adopted by the present Survey. From its shaly structure, it is eroded so easily and rapidly that it is usually covered either with its own weathered fragments, or material from the rocks above. It is only seen, therefore, in position where it is cut into by the rapid streams on the mountain side.

Immediately below the Waverly, and passing into it without any distinctly marked line of change, is the Devonian black shale. This shale is too widely extended and too well known to need any special description here. It is from one hundred to one hundred and fifty feet in thickness, with perhaps an average of one hundred and twenty-five. Like the Waverly, it is soft, and wears rapidly; so that it is usually covered, and it is difficult to obtain exposures where its whole thickness can be measured with accuracy.

At places where the dip of the rocks is very steep, and the mountain consequently low and narrow, the black shale is its

lowest rock. In this case, it is cut away to form the "Poor Valley," which uniformly occurs at the foot of the mountain, between it and the range of foot-hills, called the "Poor Valley Ridge," formed of the rocks of the Clinton or Dyestone and the Medina Groups. Usually, however, there is a thickness of from one hundred to three hundred feet of shales and shaly sandstones, containing thin bands of limestone, at the base of the mountain below the black shale, and in these the valley is cut. These rocks overlie the Clinton or Dyestone iron ores of this region, which are usually found in the Poor Valley Ridge. For a portion of the distance these ores are found at the foot of the mountain; but, as a rule, they lie in the uppermost beds of the foot-hill range.

These ores occur with great regularity along the foot of the mountain for many miles, constituting in the aggregate an enormous store of mineral wealth, that is as yet almost untouched. Their quality is good, their thickness and position such that they can be mined cheaply, and this region only lacks facilities for cheap transportation to make it one of the most prosperous and extensive iron manufacturing districts of the country.

These ores will be described more fully in another report, devoted especially to them.

The Clinton or Dyestone Group, which forms so large a portion of the rock structure of the Poor Valley Ridge, is from three hundred to five hundred feet in thickness. It is composed of shales and thin-bedded sandstones, with occasional limestones. Below these rocks of the Dyestone Group, the heavier-bedded Medina sandstone occurs, and, with the upper part of the Cincinnati limestone, which is sometimes present, completes the list of the rocks of the foot-hills of the Cumberland Mountain.

All of the above described rocks, with the exception of the Conglomerate, are seen only on the southeast or Virginia face of the mountain; but they have been thus fully described, as a knowledge of them is absolutely essential to any clear comprehension of its structure. On the northwest or Kentucky

slope of the mountain, only the Conglomerate, and the beds of sandstone and shale of the coal measures immediately overlying it, are seen. The slope on this side is much more gentle than on the other. It is usually a little less than the dip of the rocks, or nearly the same; so that but a slight thickness of rock above the Conglomerate is found on the mountain.

At the base of the mountain, on this side, is a line of fault or fold, as yet undetermined, which lies between the tilted rocks of the mountain and the overlying horizontal coal-measure rocks.

These rocks form the hills lying between the Pine and the Cumberland Mountains, variously known as the Log and the Black Mountains. They are formed wholly of coal-measure rocks, lying nearly horizontally, and show a greater thickness than in any other portion of Kentucky.

Along this line of fault or fold, between the horizontal and tilted rocks, there is usually a stream flowing, with a course parallel to the line of the mountain. A series of such streams is found along its whole length. They usually head against one another at very low gaps, run in opposite directions until they meet other streams flowing toward them, when they leave the mountain and flow across into Cumberland river.

Between Cumberland Gap and the point where the State line leaves the Cumberland Mountain there are five principal streams flowing at the foot of the mountain on the Kentucky side. They are: Clear Fork of Yellow creek, Cubbage and Browney's creeks, Martin's Fork and Crank's creek. Of these, Martin's Fork is the longest and largest, being some twenty miles in length before it unites with Crank's creek and turns away from the mountain. Unlike the others, it heads at the top of the mountain, at the point where Brush Mountain, an outlier of the Cumberland range, the structure of which has not been well determined, separates from it.

Shillaley creek, a branch of Clear Fork of Yellow creek, heads against Martin's Fork, at the top of the mountain, and the two streams divide the Brush from the Cumberland Moun-

tain. Cubbage and Browney's creeks flow at the base of Brush Mountain.

Brush Mountain, as we now know it, seems to be a duplication of the Cumberland, caused by a fault in the Conglomerate beds. It runs parallel with the Cumberland Mountain, and for a portion of its distance is about the same height; but it falls away at the upper end to a little more than half. It seems to be formed entirely of the Conglomerate and interconglomerate beds; at least, no lower rocks than these were found at its upper end, where Martin's Fork cuts deep between it and the main ridge. At this end, however, we have the Conglomerate, probably the upper member, nearly horizontal, or at least not dipping more than five degrees, showing splendid cliffs two hundred and thirty feet high, while on the other side of Martin's Fork, on the Cumberland Mountain, the sandstones dip fifteen degrees or more. The position of the rocks on the northwest face of Brush Mountain has not been ascertained as yet. The rocks of the mountain have evidently been raised to their present position by an uplift in the same manner as those of the main ridge; but it is remarkable that they should be so raised and still be so little inclined. Our knowledge of the structure of this mountain is, however, so imperfect as yet, that little can be told with accuracy regarding it.

The height of Cumberland Gap above tide is stated, in Prof. Safford's Tennessee Report, as one thousand six hundred and thirty-six feet. The height of the "Pinnacle," the mountain just above the Gap, as ascertained by repeated measurements with mercurial barometer, by Mr. William B. Page, of the United States Coast Survey service, is two thousand five hundred and one feet above tide. This measurement was made from a bench-mark of a railroad survey in the valley, on the Tennessee side. The height of the Pinnacle above this valley is one thousand two hundred and ten feet, while it is one thousand three hundred and seventy-three feet above the Yellow Creek valley, on the Kentucky side, showing this valley to be one hundred and sixty-five feet

lower than the other—a relation which the valleys on both sides of the mountain hold wherever observations have been taken all along it, until after the State line leaves it.

The Fort Hill, a knob a short distance above the Pinnacle, rises considerably higher, and is the highest point in the mountain for several miles in both directions. The mountain then falls away toward the northeast, and at Lewis' Hollow, one mile above, is about three hundred feet lower. It soon recovers its usual height of about one thousand three hundred feet, which it gradually increases towards the northeast. For the first fifteen miles above the Gap the usual dip is from twenty to twenty-five degrees to the northwest, although on the slope of the mountain local dips as high as forty-seven degrees are noticed. Gibson's Gap, four miles from the Pinnacle, is about one thousand one hundred feet above the Powell valley, while the average height of the mountain is some two hundred feet higher.

Chadwell's Gap, about thirteen miles from the Pinnacle, by way of the mountain crest, is between one thousand five hundred and one thousand six hundred feet above the Powell valley, with the general level of the mountain not more than two hundred and fifty feet above. This gap is opposite the centre of Brush Mountain, at the head of Martin's Fork.

For the next five miles the mountain continues steadily to gain in height, turning at the same time in a grand sweep round to the east, until a point is reached which is known as the White Rocks, so called from the conspicuous and precipitous cliffs of Conglomerate crowning the summit of the mountain. This is the most prominent point in the whole mountain, viewed from either above or below, extending so far out to the east as it does, and at the same time holding so great a height. The abrupt bastion-like front which this point presents, outlined against the sky, can be seen for many miles on either side. The mountain is here nearly two thousand feet above the Powell valley, and, by barometrical measurements by Mr. W. B. Page, United States Coast Survey, is shown to be three thousand four hundred and sixty

feet above sea level. The sweep of the mountain round to the east is due to a change in the direction of the dip of the rocks, which gradually change from northwest to north, and from north to north twenty degrees east, which is the direction at this point, while the angle of dip is quite gentle, being only from thirteen to fifteen degrees.

The Conglomerate capping the ridge forms at one place a cliff nearly four hundred feet in height, which is a little more than perpendicular, overhanging a few degrees. These cliffs are unusually prominent along the face of the mountain for the next three or four miles.

Soon after passing the White Rocks point the dip of the rocks once more changes to the west of north, and the course of the mountain range turns in sympathy back toward the northeast.

The dip of the rocks becomes much steeper, and the mountain loses proportionally in height. At Britton's Gap, about seven miles above, where the mountain was crossed on this journey, the rocks are vertical, or, in some cases, overthrown and dipping to the southeast about eighty degrees. The height here, by aneroid barometer, is only nine hundred and fifty feet above the Powell valley, or about half the height at the last point of observation.

At Brierfield's Gap, three miles above this, the height of the top of the mountain is only nine hundred feet above the valley. The Poor and the Powell valleys, on the Virginia side of the mountain, grow narrow with this change in the dip, as only the edges of the rocks are presented for erosion. The range of foot-hills, called the Poor Valley Ridge, follows in miniature the changes in elevation of the mountain, rising to about four hundred feet at the White Rocks, sinking away to about two thirds this height at the last described places, and then rising again to nearly five hundred feet at the next elevation in the mountain at Crank's Gap, which is about ten miles above. Here the dip of the rocks has once more become very gentle, from eighteen to twenty-five degrees, and the mountain is about one thousand five hundred to one thou-

sand six hundred feet above the valley. Its elevation above sea level is not known, but it is probably somewhat less than the White Rocks point. The mountain at this point is very broad—fully twice its usual breadth. Where the rocks were steeply inclined, or vertical, no rocks higher than the Conglomerate seem to have shared in the disturbance, or, if they did, all traces of them have been worn away. The mountain is consequently narrow, and Martin's Fork, the stream at the base of the mountain, flows close to the top of the Conglomerate in a very narrow valley, so narrow that there is but little arable land in it. The mountain along here shows, from the Kentucky side, a succession of splendid outcrops of Conglomerate, standing on edge, or very steeply inclined. It holds this character along the lower part of Crank's creek also, where that stream is almost exactly similar to Martin's Fork; but along its upper portion the valley is wider, and is cut in rocks geologically higher, the shales and shaly sandstones above the Conglomerate. A considerable thickness of these rocks, here, share in the elevation of the Cumberland Mountain, and it is owing to this fact, together with the slight degree of dip, that the mountain at Crank's Gap is so broad. The road from Mt. Pleasant, Kentucky, to Jonesville, Virginia, crosses at this gap. It is in reality no gap at all, but simply a place where the road crosses the mountain, and that at one of its highest points. This point runs well out to the east, and from the summit the Cumberland range can be seen down to Speedwell, in Tennessee, twenty miles below Cumberland Gap, a total distance of forty or fifty miles.

About four miles above this point the State line leaves the Cumberland Mountain, and crosses at a low gap at the head of Crank's creek, between that stream and one of the branches of Powell's river, to the Little Black Mountains.

The Cumberland Mountain turns still further to the east, and is henceforward known as the Stone Mountain. The so-called gaps, which have been mentioned, are usually only slight depressions in the crest of the ridge, through which the

mountain paths or trails cross. For thirty-five miles above Cumberland Gap there is no gap of more than three hundred feet depression below the general level of the crest, nor is there in this distance any wagon road across the mountain. Between thirty-five and forty miles above, however, the North Fork of Powell's river has cut through the mountain and made a water-way known as Pennington's Gap. The mountain, here, is only about one thousand feet high, and the rocks, from the Silurian to the Carboniferous, are nearly vertical, with a strike north 30° east. The North Fork of Powell's river, which cuts through here, drains a considerable area lying between the Little Black and the Cumberland Mountains, known as the "Pocket." The line of disturbance does not, here, seem to reach the rocks much higher than the Conglomerate. In this gap a coal is exposed, standing vertical, about thirty-five feet below the upper Conglomerate. The coal is reported thirty inches thick. It is said that there are two other coals found vertical near this point, but they were not seen by the writer.

The scenery at Pennington's Gap is grand in the extreme. The river has made a narrow cut through the mountain, in which the walls of vertical Conglomerate are seen hundreds of feet high, rising far above the rocks on either side, rugged and bare.

Eighteen miles above, at the Big Stone Gap, in the Cumberland or Stone Mountain, another fork of Powell's river, called also the North Fork, and sometimes the Roaring Fork, has cut a similar water-gap through the mountain, which is here about the same height as at the last place; but the rocks are not quite so steeply inclined, dipping only about sixty degrees. The stream at this gap drains a considerable area, lying between the Big Black and the Stone Mountains, and the divide between the waters of the Powell and Guest's rivers, the latter a tributary of the Clinch.

This is the last water-gap cut through the Cumberland Mountain, which extends about twenty miles further to the

east, and finally ends near Guest's river, in Wise county, Virginia.

These two gaps are the natural ways to give access to the boundless stores of coal which lie north of the Cumberland Mountain. Through them, with little expense, the coal can be brought, which will, in the future, supply fuel to the great non-coal-bearing country to the south. Above the Big Stone Gap the Powell valley gradually narrows, the Powell Mountain or range approaches the Cumberland, and finally unites with it above Little Stone Gap, at the extreme head of Powell's river.

From Big Stone Gap the Cumberland Mountain is low, rarely over one thousand feet in height above the valley. About ten miles from this last mentioned point the wagon road to Gladesville crosses the mountain at Little Stone Gap, which is cut about three hundred to four hundred feet below the general level of the crest, and is about six hundred feet above the valley.

The lowest rock seen on the south face of the mountain is the Devonian black shale. It is the surface rock for a considerable area near the head of the valley. It dips to the north very slightly; but above it we have the Waverly and the St. Louis limestone, increasing in steepness of dip as we ascend. The limestone dips about forty-five degrees nearly due north, while on the north slope of the mountain, a few hundred yards after passing the gap, the Conglomerate and inter-Conglomerate beds are standing vertical, or dipping to the north from eighty to eighty-five degrees. Between the Conglomerates there is a coal exposed by the roadside, standing nearly vertical. It was seen about thirty inches thick.

The only published information in regard to the geology of this region which has come to the notice of the writer, is a paper by Prof. J. P. Lesley, the distinguished State Geologist of Pennsylvania, read before the American Philosophical Society, April 21st, 1871, on the geological structure of Tazewell, Russel, and Wise counties, Virginia.

In this valuable and interesting paper, Prof. Lesley gives a section at Little Stone Gap, which he states has not been seen by him, but is published from information given to him. This section correctly shows one vertical Conglomerate with the coal above; but it also shows a fault running lengthwise through the mountain, with the lower Silurian limestone forming the south face of the mountain. From the description given just above, it will be seen that this section is very incorrect.

There is no fault running lengthwise through the mountain; on the contrary, it shows at this place only what may be called the normal structure of the Cumberland Mountain. There is no Silurian limestone exposed on the mountain at this place. The lowest rock seen, both geologically and topographically, is the Devonian black shale.

Prof. Lesley's informant has evidently mistaken the massive St. Louis limestone, which occupies its usual place on the south face of the mountain, for the lower Silurian, and Prof. Lesley himself was the more ready to accept the statement, supposing this to be the westward prolongation of the great Clinch River fault, which terminates the coal field above Guest's river, beyond the end of the Cumberland or Stone Mountain.

The distance from the end of the Cumberland Mountain, at Guest's river, to Cumberland Gap, is about eighty miles. From Cumberland Gap, to the southwestern end of the same mountain in Tennessee, as stated* by Prof. Safford, is about forty miles. Its total length is, therefore, about one hundred and twenty miles, in which distance it is broken by only five gaps, deep enough to be more than serrations in the crest line. These are: Bruce's and Big Creek Gaps, in Tennessee, Cumberland, Pennington's, and Big Stone Gaps. Of these, all except Cumberland Gap are water-gaps, while it is cut three fourths of the distance down from the top of the mountain.

*The reader should keep in mind the distinction between the Cumberland Mountain as described here and the "Cumberland Table Land" which occupies so large a portion of the area of Central Tennessee.

It affords one of the most feasible passages for a railroad, for the reason that, while the other gaps afford a much easier passage through the mountain itself, yet, to get to them, a railroad would be compelled to cross the much higher mountains between the Cumberland river and mountain, while at Cumberland Gap the Yellow Creek valley affords an easy way, with light grades to the very foot of the mountain.

There is, perhaps, a better route for a railroad offered through Pennington's Gap, crossing the divide between the waters of Powell and Cumberland rivers at a very low gap at the head of Crank's creek, which flows at the base of the mountain on the north side; but this is somewhat less direct than via Cumberland Gap.

Above Guest's river, in Virginia, the coal field terminates with a fault which brings the rocks of the Knox series (using the Tennessee nomenclature) up against the coal measures. This fault is unaccompanied by any great topographical elevation, and the disturbance in the rocks of the coal measures is comparatively slight, not extending far back north of the fault. The limestones on the south side of the fault, however, are very much disturbed, showing numerous local flexures and cross-folds close to the line, while further back they dip steeply away to the southeast. From here south to Clinch Mountain, along the road to Abingdon, Virginia, the rocks of the Knox series, and, in a few cases, the Trenton limestone, are seen. The valleys of the small streams are cut in the imbricated edges of these rocks, which are repeatedly faulted, the same series of limestones and shales being crossed a number of times, and usually dipping in the same direction, to the southeast.

At Clinch Mountain the geological series as high as the Devonian shale is represented, while just beyond, south of the Holston river, another fault occurs, which once more brings the lower or middle Knox series to the surface, and we then have a repetition of the features just described: the rocks dipping to the southeast, and occasionally faulted; the upper part of the Knox series and the Trenton limestone

forming, for the most part, the surface rock as far south as Abingdon. The Clinch Mountain here, as further southwest, is capped and shaped by the massive Medina sandstone, which, with the other rocks of the mountain, dips to the southeast. The principal geological and topographical features of this region are well shown in the map accompanying the paper of Prof. J. P. Lesley already referred to.

The fault, which ends the coal measures, lies on the north side of Clinch river, for the most part close to it, and at one point even crosses to the south side of the river. It is shown by Prof. Lesley to extend along the north side of the river to its head and beyond. About twenty miles above Guest's river the fault line runs several miles north of Clinch river, leaving room between it and the river for a fertile valley, known as New Garden. This is principally drained by Lewis creek. The fault line crosses at the very head of this creek, nearly half way up the dividing ridge or the Big Mountain, the divide between the waters of the Clinch and Big Sandy or Chatterawha rivers. The exact height of this mountain was not determined, but it is probably over one thousand five hundred feet above Clinch river, and the fault line occurs about six hundred feet up. Prof. Lesley's map shows the line about three miles too far to the south at this place. It is, however, a region where he states that he has made no detailed examinations.

THE BLACK MOUNTAINS,

Lying between the Cumberland and the Pine Mountain, which will be hereafter described, is a series of hills with the peculiar irregular topography of horizontal rocks, known in Kentucky as the Black and Log Mountains, in Tennessee as the Poplar Mountain, and in its southern continuation as the Cumberland Table Land. Below Yellow creek they are called the Log, and above, the Black Mountains.

They rise to a height greater than either the Pine or Cumberland Mountain, and are formed of the horizontal or nearly horizontal rocks of the coal measures, for the most part sand-

stones or sandy shales. They present a greater thickness of coal-measure rocks, and a greater number of coals, than are known in any other portion of the State. They have not, however, been studied in sufficient detail to enable us to give an accurate general section, showing the position and full number of the coals.

The Log Mountains have been studied at a few places in some detail by Mr. Crandall, of the Survey, who has found a total of seventeen coals, and the section is by no means complete.

Above Yellow creek, the hills which lie between that stream, Browney's and Puckett's creeks, and Martin's Fork of Cumberland river, are first called the Black Mountains. Above Martin's Fork, the ridge between the Cumberland Mountain and Clover Fork of Cumberland river is called the Little Black Mountain, while that between Clover and Poor Forks is named the Big Black. The Little Black, to the head of Clover Fork, is the dividing ridge between the waters of the Cumberland and Tennessee, while the Big Black occupies this position from the head of Clover Fork to the head of Poor Fork of Cumberland.

Beyond the head of Poor Fork a series of irregular hills or mountains are seen between the different branches of Russel Fork of Chatterawha or Big Sandy river, the system and names of which are not yet known. They are by no means so prominent or high as the Black Mountains; but, like them, they are formed of comparatively undisturbed rocks.

Of the Black Mountains below Martin's Fork little was seen. At one place, near Wilson's or Browney's creek, a section of five hundred and sixty feet was measured, containing six coals, ranging from one to three feet in thickness. This section was by no means complete, and it is altogether probable that other coals will be found in the covered space. These hills apparently are about one thousand two hundred feet high. Much thicker coals than seen in this section are reported on good authority near Mt. Pleasant.

The Little Black Mountain, at Child's Creek Gap, where the trail from Pennington's Gap to Clover Fork crosses, is one thousand four hundred feet above the Powell river, and the general average of the range adjacent is from two hundred to three hundred feet higher.

In descending from Child's Creek Gap to Clover Fork, the positions of six coals were seen, but the coals themselves were generally covered; one was seen thirty-seven inches thick, and another is reported to be five feet, but it was not seen.

The Little Black Mountain is said to rise in height until it unites with the Big Black at the head of Clover Fork, at which locality is said to be the highest knob in that region.

The Big Black Mountain, where first crossed at Witt's Gap, is about one thousand nine hundred feet in height, above the Poor Fork of Cumberland river.

At the head of Looney's branch of Poor Fork this mountain reaches the unusual height of two thousand two hundred feet above Poor Fork, measured with an aneroid barometer.

In this mountain and its spurs were seen a number of excellent coals of unusual thickness, sufficient to show that this portion of the State is one of the most richly endowed in stores of mineral fuel.

Near Elijah Creech's, on Looney's branch, in Harlan county, three coals were seen, one forty inches thick, without any parting, and of excellent quality; another one reported the same thickness, but of which the top only was seen, and a third which presented the following section:

Coal	25	inches.
Parting	7	"
Coal	11	"
Shale	22	"
Coal	3	"
Parting	2	"
Coal	11	"
Shale	13	"
Coal	12	"
Parting	4	"
Coal	37	"
Bottom fire-clay	—	"

A total of eight feet three inches coal in twelve feet three inches of mingled coal and shale.

About two and one half miles above, near Joseph Blair's, in the bed of the same branch, a coal is washed bare, which shows between five and one half and six feet of clear coal, free from parting. It was inclined a little as it lay in the bed of the stream, so that measurement could not readily be made more exact than given above. It is of excellent quality, a rather "fat" caking coal, and, so far as seen, quite free from pyrites.

On the opposite side of the mountain, on Preacher creek, a coal is exposed in the bank of the creek, six feet three inches thick, with only a thin parting of about one inch. Whether this be the same coal as that last described is uncertain; it is, however, apparently too high.

Near Big Stone Gap, on one of the creeks flowing into the North Fork of Powell's river, a coal is reported nine feet thick; but it was not seen by the writer.

What is the exact geological level of the base of these mountains has not yet been accurately determined. It is probably some distance above the top of the Conglomerate, which we find rising from beneath the surface on both the Pine and Cumberland Mountains. Assuming, however, that this Conglomerate is just at the base of these mountains, and adding the thickness of the Conglomerate and inter-Conglomerate beds to the thickness of rocks on the Black Mountains, we have a total of over four thousand feet of coal measures in this region, which is over twice as great a thickness as is yet known anywhere else in the State, outside of this area between the Pine and Cumberland Mountains.

PINE MOUNTAIN.

In its geological structure and topographical type, Pine Mountain is almost identical with the Cumberland.

It is a long, straight, monoclinal mountain, formed by an uplift of the rocks from the Carboniferous to the Silurian, along a crack or line of fault in the crust of the earth, running in a northeast and southwest direction, parallel with the lower portion of Cumberland Mountain.

On the northwest of this fault lie the comparatively undisturbed coal measures, while on the southeast, the tilted rocks forming the mountain dip steeply away to the southeast. The dip is, therefore, in the opposite direction to that of the rocks of the Cumberland Mountain, and we have reäppearing here the same rocks which plunged underground at the base of that mountain.

The two form in reality the two edges of a long basin or valley, with, in the lower part, an average width of about ten miles from crest to crest.

The Pine Mountain is much more regular in its outline than the Cumberland. Its crest is almost a straight line for its whole length, and it presents few great irregularities in height. In its lower part, along the Cumberland river, it has an average height, so far as seen, of about one thousand two hundred feet, which gradually rises to about one thousand four hundred to one thousand five hundred feet at its upper end, where it lies between branches of the Chatterawha or Big Sandy river.

The course of the fault along which the mountain runs is about north 30° east. The mountain extends in Kentucky from the State line, where Clear Fork of Cumberland river cuts a water-gap through it, to the Russell Fork of Chatterawha or Big Sandy river, a distance of about one hundred and ten miles. It extends probably twenty-five miles farther in Tennessee. It is, therefore, longer as well as straighter and more regular in outline than the Cumberland Mountain. At the upper end it is known as the Laurel, and sometimes as the Cumberland Mountain, a circumstance which leads to much confusion, the cause of which has never before been understood.

Pine Mountain is also accompanied by a series of parallel streams flowing at its base on both sides. Beginning where the Russell Fork of Chatterawha river cuts a deep cañon through the massive sandstones at the terminus of the mountain, we find the Pound Fork flowing at its base on the south, with Elkhorn creek on the north. Pound Fork heads in the

Big Black Mountain, against the Poor Fork of Cumberland; which flows at the foot of the mountain, in the opposite direction, until it unites with Clover and Martin's Forks, and forms the Cumberland river. This, in its turn, follows the foot of the mountain, until it cuts through at Pineville and leaves it, flowing to the north and west. At the foot of the mountain on the north, beyond the head of Elkhorn creek, the North Fork of Kentucky river flows for a short distance. It is then succeeded by its branches, Kingdom-come creek, King's creek, and Line Fork, which successively occupy the foot of the mountain for the next twenty-five miles. Beyond the head of Line Fork, Straight creek, a branch of the Cumberland, follows the foot of the mountain for about thirty miles, until it meets the river, just as it emerges from the gap through the mountain at Pineville.

As already stated, the rocks of this mountain are essentially the same as those of the Cumberland. There is this difference, however, that the lowest rocks of the Cumberland Mountain have not yet been found on the Pine. The general dip of the rocks is twenty to twenty-five degrees to the southeast, subject, however, to local variations, which do not seem to be so frequent as in the Cumberland. The crest-forming rock is the Conglomerate, which presents all its peculiar characteristics. Below this the inter and Sub-conglomerate shales, St. Louis limestone, Waverly sandstone, and Devonian black shale, occur in the same order, and approximately the same thickness, as on the Cumberland.

Below the Devonian black shale the rocks are usually covered, so that it is really not yet known what is the thickness and character of the rocks between this shale and the base of the mountain. The distance from the black shale to the drainage level varies from one hundred and fifty to three hundred and fifty or four hundred feet. At a few places exposures of shales and shaly sandstones have been seen, but a complete section has not yet been obtained. These rocks correspond probably to the shales and sandstones above the Clinton or Dyestone ores on the Cumberland Mountain. At

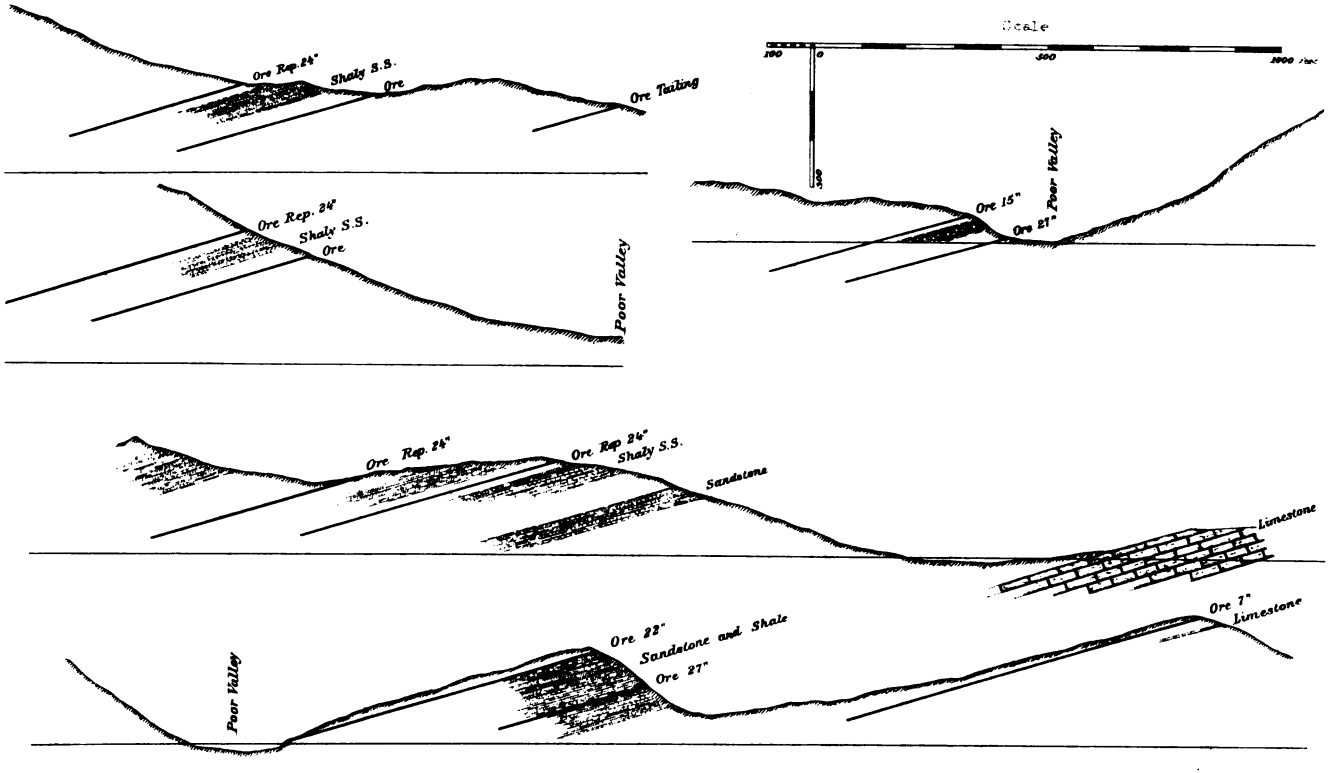
some places it seems probable that the lift of the mountain is sufficient to bring the ores above the drainage; but they are covered by the talus from the rocks above, and will not be found without digging for them. The ores have not been found on Pine Mountain, as yet, by any member of the Survey in Kentucky, nor is there any authentic report of their discovery by others.

In Tennessee, near Elk Gap, Prof. Safford reports the uplift of Pine Mountain to be such as to bring the Cincinnati and Trenton limestone above the drainage, so that the Clinton ore is also above. He reports it at this place three feet thick. There is, therefore, no good reason why, in some localities at least, the ore may not be found in the Pine Mountain in Kentucky, although there are undoubtedly places where the uplift is not sufficiently great to bring it to the drainage level.

There is no series of foot-hills corresponding to the Poor Valley Ridge, at the base of Pine Mountain; on the contrary, the hills of the coal measures, with the peculiar irregular topography of horizontal rocks, approach close to the foot of the mountain. In one case, on Straight creek, a horizontal coal bed three feet thick was seen at the foot of the mountain, between it and the creek. The same thing is reported at several places on Elkhorn creek, in Pike county.

This shows that the stream has run to the north of the fault, and that this is very close to the mountain. It proves also that the retreat of the crest line of the mountain, under the erosive agencies which have been so long at work upon it, has been but a short distance, hardly more than a half mile back from the fault line.

Cumberland Mountain, on the other hand, from the position of the rocks in the Powell valley, bears evidence of having retreated from the southeast several miles. Powell river runs in a wide anticlinal valley, the rocks of which dip away from the river in each direction. The river runs in the Knox Dolomite, and we have the series, from this rock up to the Carboniferous, repeated on both sides without any fault or break of consequence. This affords pretty conclusive evidence that



SECTIONS SHOWING THE POSITION OF THE FOSSET ORE BEDS IN THE VICINITY OF CUMBERLAND GAP TO ACCOMPANY REPORT OF P.N.MOORE

GEOLOGICAL SURVEY OF KENTUCKY.

N. S. SHALER, DIRECTOR.

REPORT

ON THE

IRON ORES

IN THE

VICINITY OF CUMBERLAND GAP.

BY P. N. MOORE.

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ON THE IRON ORES IN THE VICINITY OF CUMBERLAND GAP.

The iron ores of economical importance in this region lie on the southeast of Cumberland Mountain, usually in the range of foot-hills known as the Poor Valley Ridge, which is almost always seen at the base of the mountain. Occasionally, this ridge disappears, and we find the ores on the flank of the mountain proper, near its base; but their occurrence in this position is exceptional.

The ores are, consequently, in Virginia and Tennessee; but as they occur so close to the Kentucky line, and are so intimately connected with Kentucky interests, in that they cannot be fully developed without the use of Kentucky fuels, an examination was made of them for a few miles up and down the mountain, from Cumberland Gap, to ascertain something as to their method of occurrence, quantity and quality, and to determine the capabilities of the region to sustain an iron-manufacturing industry.

The manufacture of iron from these ores with charcoal fuel has been, for a long time, carried on in this vicinity in a small way, at a number of places; both pig iron and blooms having been produced. It is, however, upon coal as a fuel that the permanent iron industry must be founded, and the coal which will, in the future, smelt the ores along the mountain for a considerable distance below, and for a still greater distance above Cumberland Gap, must come from Kentucky. There is no coal to the southeast in either Tennessee or Virginia, and Cumberland Gap affords the most feasible passage by railroad through the mountain, from the ore to the great Kentucky coal field.

Such being the case, these ores become of almost as much importance to Kentucky as to the States in which they are

situated, especially when we consider that their development is dependent largely upon a Kentucky railroad enterprise to give them access to market. Either of the projected railroads through Kentucky to Cumberland Gap, will find in the transportation of these ores, and of the iron made from them, one of the most important sources of revenue.

The ores of this region are stratified hematites, belonging to the Clinton Group of the Silurian formation, a group which has been designated as the Dyestone Group by Prof. Safford, in his report on the geology of Tennessee. The ore is variously known as the Dyestone or Fossil ore, and sometimes simply as the Red ore. It is called the Dyestone ore, from the fact that it is sometimes used for dyeing purposes by the residents of the region where it is found.

The rocks with which it is associated are usually shales, sometimes calcareous, which occasionally pass into thin-bedded sandstones. There are also occasional interstratified thin beds of limestone, which increase in frequency toward the lower part of the series, and below the ores.

The thickness of the group in Tennessee, as stated by Prof. Safford, varies from two hundred to three hundred feet. In this vicinity it is usually thicker, ranging from three hundred to five hundred feet. These rocks pass almost imperceptibly into the Medina sandstone below. This sandstone is here thin-bedded, and less marked in every way than it is further southeast, where it is the massive determining rock of Clinch Mountain; but it is still heavy enough to form, with the lower portion of the Clinton beds, the Poor Valley Ridge, or foot-hill range of Cumberland Mountain. The "Poor Valley," between the foot-hill and the mountain, is excavated in the thin-bedded, soft, and easily eroded Clinton rocks, and it is to their silicious nature, and the soil resulting from them, that the infertility of the valley is due. The Devonian shale and the Waverly also help in the formation of the valley to a certain extent, but the Clinton shales are particularly the valley rocks. Usually the shale above the ore occurs in the valley, and the upper ore (of the three to be hereafter described),

with a thin but hard sandstone immediately above it, is the highest and crest-forming rock of the Poor Valley Ridge.

As already stated, the ore occurs in beds or layers, interstratified with shales and limestones. It differs much in quality in the different beds; but when at its best, is an oölitic, greasy-feeling, fossiliferous hematite, formed at places almost entirely of fragments of crinoid stems. Other fossils are numerous, but by no means reach anything like the proportion of the crinoidal remains.

The ore has not been studied in sufficient detail over a large area, where it has been opened in depth, and the overlying rocks are fully exposed, to enable the writer to form a theory of its formation satisfactory in every respect; but the structure of the ore, in most cases, indicates, beyond reasonable doubt, that it was originally a bed of fossiliferous limestone. The original limestone has been dissolved and removed by the solutions which brought the iron and deposited it in the form and place of the limestone. The iron has probably been derived from the rocks above, and has been gradually removed by a process of leaching.

This ore is by no means a local deposit. It is characteristic of the rocks of this period, from New York to Alabama, and it is also found in the same formation in Wisconsin, of a quality that can hardly be distinguished from the New York or Tennessee ore. This marked uniformity of quality and position of the ore show that the waters, at the time of the deposition of these rocks, must have been very uniformly charged with iron over an area hundreds of square miles in extent. There is no similar formation in which iron ore is distributed with anything like so great uniformity, or of which it is so characteristic. Other ores are found usually connected with rocks of a particular formation, but they are by no means coextensive with that formation; they are, on the contrary, "pockety" and erratic. This, however, both in quality and position, maintains its identity along the parallel mountains of the Appalachian series for hundreds of miles. In the aggregate, therefore, it presents a mass of ore which is

practically inexhaustible, and is unequaled by any other deposit in the country.

In New York and Pennsylvania ore of this age is largely worked for the supply of blast furnaces; but south of those States it is almost untouched, although in Virginia and Tennessee a number of small charcoal furnaces and forges have been using it for many years past. Their consumption is so small that, in comparison with the vast amount remaining, what ore they have used is too small for notice.

There are usually found in the region under consideration three beds of ore. These have been found to extend with considerable regularity for five or six miles each side of Cumberland Gap. Whether they are persistent at a greater distance above the Gap than this is not yet known. Ore is found in good thickness at many places above; but the sections taken have not been detailed enough to prove the existence of more than one bed, although there is no reason to doubt that the others will be found when properly sought for. Below Cumberland Gap, at Speedwell Furnace, two ores have been worked, apparently corresponding to the middle and upper of the three above mentioned, with the distance between them considerably increased.

The positions and relative distances apart of the three ores are shown in the sections of the accompanying plate. These sections were all taken within a few miles of Cumberland Gap, and the most of them within one mile and a half. It will be seen from them that the ores are sometimes found at the foot of the mountain proper, and sometimes in the Poor Valley Ridge.

They are of the most value when they occur in the ridge, for the reason that there is then a larger amount of the ore above drainage level, where it can be much more easily and cheaply mined. It is also probable that, at a certain depth below the drainage level, the soft fossiliferous ore becomes hard, calcareous, and poor in iron; in other words, that it approaches the condition of the original limestone, and is no longer profitable to work in the furnace. This opinion is

not founded upon observations in this immediate region, for mining has not yet been carried deep enough to ascertain the fact; but it is based upon reports of mining operations upon the same ores at other and widely separated places. When the ore occurs in the Poor Valley Ridge, it dips nearly with the slope of the ridge on the mountain side, so that there is a large amount of it at a uniformly small depth below the surface; while, when it is in the mountain, it dips directly back from the surface; and even if it does not change its character, and become lean, it will soon become difficult and expensive to mine.

It will be seen from the accompanying sections, that the distance between the upper and middle ores varies from seventy to one hundred and five feet. The distance between the middle and lower ores is from two hundred to two hundred and fifteen feet.

The upper ore is the most valuable of the three in this region. It is soft, very fossiliferous, and much richer in iron than the middle ore, although it is not nearly so thick. It has been seen by the writer varying from fifteen to twenty-two inches in thickness, and it is reported on good authority at one place, where a full measurement could not be obtained at the time of visit, to be twenty-six inches thick. It is the only ore that has been worked in the furnace at Cumberland Gap. There is such an abundance of it in the neighborhood, and it is won so cheaply, that there has been no inducement to attempt to utilize the middle ore, which is both thicker and leaner than the upper. It is hard, silicious, and not very fossiliferous. It has been seen by the writer twenty-seven inches thick, and is reported, at other places, to be thirty inches. It seems to have been originally a silicious limestone, which is now impregnated with iron. It apparently corresponds to the "hard ore" of this same period in Pennsylvania, while the upper ore seems to be the counterpart of the "soft ore" of the same State.

At Speedwell Furnace, about twenty miles below Cumberland Gap, the middle or hard ore has been used in consider-

able quantities to mix with the soft ore, a purpose for which it is well adapted. This is the way in which the two ores can be profitably utilized. The hard ore, although richer and more valuable than is now commonly supposed by iron-makers in that region, is yet too silicious to work easily in the blast furnace alone. Mixed with the soft ore, however, it can be used with very good results.

Owing to its greater thickness, there is a larger quantity of this ore in a given area than of the upper ore, although its specific gravity is not so great.

The lower ore, which occurs about two hundred feet below the middle, is but little known, and never, to the knowledge of the writer, has been mined in this region. In quality, it very much resembles the soft upper ore; so much so, that specimens of it can scarcely be distinguished from the upper ore. It is, however, thin, not having been seen by the writer more than six or seven inches in thickness. Where this ore occurs in the mountain proper, and dips away from the surface, it will be of little value, as it is too thin to be profitably mined at present under such circumstances; but where, as shown in the lowest section of the accompanying plate, it lies near the surface of the ridge for a considerable distance, it can be worked at very reasonable rates, and a large amount of ore be obtained; as, with a thickness of from six to seven inches, each square yard covered by the ore will yield nearly half a ton.

The lowest section of the accompanying plate shows the position of the ores in the Poor Valley Ridge, at Cumberland Gap, just below the Tazewell road. It will be seen that both the lower and the upper ores lie here in the most favorable position possible for easy and cheap mining, as they are both near the surface, and only covered by a slight thickness of overlying material. The upper ore has been mined for the furnace at the Gap, beginning down in the valley and working upwards towards the crest of the hill, throwing the earth behind as each successive bench of ore is raised. In this way

the pits or benches are easily drained. The cost of mining the ore here is only fifty cents per ton.

This fortunate position of the ores in the ridge is continued for several miles below Cumberland Gap, interrupted occasionally by changes in the topography, where longer spurs than usual put out from the mountain, between streams, but returning again to their position on the ridge as soon as these are passed.

The section just referred to shows the slope of the ridge on which the ore lies to be about six hundred feet in width. At places below, on the ridge, it will exceed this measurement by nearly one half. It will, therefore, be safe to estimate the breadth above drainage of the ore stratum running along this slope of the Poor Valley Ridge at six hundred feet, or two hundred yards. The ore varies in thickness from fifteen to twenty-four inches, and it is probably under rather than over the average for this region to place it at eighteen inches; but in the following estimate of the quantity of ore in this ridge it is essential to keep within limits of safety. The ore has, according to the determination by Mr. Talbutt of two samples, a specific gravity of 3.94 and 3.91. Assuming a specific gravity of 3.9, a thickness of eighteen inches, and a breadth of ore belt of six hundred feet, there will be present, for each mile of the ridge holding the ore in this position, 538,319 gross tons. This estimate is, however, too great, in that it assumes the ore stratum and the surface of the ridge to be continuous, unbroken by ravines, gullies, and streams. No accurate estimate of the amount lost in this way can be made without a detailed contour map; but it is believed that one fourth will be more than ample to cover it. Deducting one fourth as lost in this way, we still have 403,740 tons of ore present per mile of the ridge. This estimate is made exclusive of any ore below drainage at the foot of the mountain proper, for the reason that it is as yet uncertain to what depth the ore will be found soft and rich; and it will be a long time before there is any demand upon it in this position. It is

equal to, or greater than the soft ore. It should be distinctly remembered, however, that these last estimates are mere approximations, and are not based upon sufficient data to render them worthy the credit due to the first estimates, which were founded upon more detailed observation.

QUALITY OF THE ORE.

The soft ore is of excellent quality, producing about fifty per cent. of iron, and working easily in the furnace. The hard ore is more silicious and poorer in iron, and will probably require admixture with the soft ore, to enable it to be smelted successfully. The quality of three samples of ore, from the immediate vicinity of Cumberland Gap, is shown by the following analyses by Dr. Peter and Mr. Talbutt, from samples collected by the writer:

	1	2	3
Iron peroxide	73.935	77.380	47.965
Alumina	5.776	3.941	2.130
Lime carbonate	4.510	.420	1.230
Magnesia	.266	. . . . .	.194
Phosphoric acid	.319	.319	.575
Sulphuric acid	. . . . .	. . . . .	trace.
Silica and insoluble silicates	11.730	15.960	43.690
Combined water	3.850	2.500	4.000
Total	100.386	100.520	99.784
Metallic iron	51.754	54.166	33.575
Phosphorus	.140	.140	.251
Specific gravity	3.914	3.942	3.190

No. 1 is the upper or soft ore from the valley near the Virginia road, a short distance above Cumberland Gap.

No. 2 is the same ore from the ridge below Cumberland Gap.

No. 3 is the middle or hard ore from the ridge near the same place as last noted.

The above analyses show in all the samples a workable per centage of iron. The amount of phosphorus present is

decidedly less than is usually characteristic of the ore at other places. As a rule in other States, this ore is decidedly phosphatic, and produces a cold-short iron; but it proves to be exceptionally pure in this vicinity.

For comparison, there is herewith appended the following analysis of the hard ore of the same geological period from Dysart's mine, Huntingdon county, Pennsylvania, by Prof. Percifer Frazer, of the University of Pennsylvania:

Sesquioxide of iron	38.48
Protoxide of iron	4.37
Silica	37.99
Alumina	9.56
Lime	1.06
Magnesia	a trace.
Alkalies	2.54
Phosphoric acid	1.48
Sulphur	.05
Loss by ignition	4.50
Total	100.04
Metallic iron	30.34

It will be seen that it is very similar in constitution to No. 3 of the analyses just before given, except that it contains a larger proportion of alumina and phosphorus.

There is also herewith given an analysis, by Dr. Peter and Mr. Talbutt, of the pig iron made at the Cumberland Gap Furnace from the soft ore of the upper bed. It is a cold-blast charcoal iron, of excellent quality and great strength. It is used for car-wheel purposes.

ANALYSIS OF COLD-BLAST, CHARCOAL PIG IRON, CUMBERLAND GAP FURNACE.

Iron	92.828
Graphitic carbon	3.260
Combined carbon	.840
Silicon	1.668
Slag	.480
Manganese	.153
Aluminum	.766
Calcium	.112
Magnesium	.270
Phosphorus	.145
Sulphur	.068
Total	100.590

This iron is hauled to the Powell river and boated down to market at Chattanooga at times of high water. It is manufactured very cheaply at the furnace; but the expense, risk, and uncertainty of the transportation to market, greatly reduce the profits on its manufacture, and leave only a narrow margin at present prices for iron.

The cheapness with which iron can be manufactured at this place will be realized when it is understood that the ore is delivered at the furnace throat for one dollar per ton, thus costing only two dollars to the ton of iron for the ore.

Furnaces lower down in Tennessee and in Alabama, smelting ore of this kind with coal or coke, produce iron at as low or lower prices than in any other part of this country. It is stated, on very competent evidence, that the Roan Iron Furnaces of Rockwood, Tennessee, make iron for less than fifteen dollars per ton.

With a railroad from the central part of the State through the mountain at Cumberland Gap, so that the Kentucky coal can be used with this ore, this locality can produce iron as cheaply as any other point in this highly favored valley, and can place it in market at lower rates.

It is destined to be one of the great iron-manufacturing regions of the country, and only awaits facilities for the transportation of its product to inaugurate a wonderful development of its resources in this direction.

GEOLOGICAL SURVEY OF KENTUCKY.

N. S. SHALER, DIRECTOR.

REPORT

ON THE

GEOLOGY OF A SECTION

FROM

NEAR CAMPTON, WOLFE COUNTY, TO THE MOUTH OF TROUBLESOME CREEK, BREATHITT COUNTY.

BY P. N. MOORE.

PART VI. VOL. IV. SECOND SERIES.

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REPORT ON THE GEOLOGY OF A SECTION FROM NEAR CAMPTON, WOLFE COUNTY, TO THE MOUTH OF TROUBLESOME CREEK, BREATHITT COUNTY.

The examination upon which this report is based was made late in the fall of 1875, for the purpose of determining something of the number and character of the coals which would be reached by a projected line of railroad, from the central part of the State, to the coal fields of the Kentucky river in Breathitt county. Owing to the lateness of the season, and the lack of time, as well as to the fact that there is no map of this region by which observations can be located with any exactness, the examination was only little more than a detailed reconnoissance. It is, therefore, highly probable, when the region comes to be examined in detail, that corrections will have to be made in the following report and the accompanying section, though it is believed that, in their general features, they are essentially correct.

As there are several different routes for the projected railroad under advisement—all, however, crossing the divide between the Red and Kentucky rivers, and subsequently the Kentucky river itself—a section of the rocks was made along this divide, from the head of Chimney Top Branch of Red river to Frozen creek; thence across the Kentucky river, and up on the south side to the mouth of Troublesome creek, which enters from the opposite side.

With the comparative merits of the different lines from an engineering stand-point this report does not deal. They will all encounter more or less difficulty in surmounting the dividing ridges between the streams. They all will reach substantially the same coal-beds, but they differ somewhat as to the

distances at which they will first strike the outcrops of the coals.

Each of the lines encounters the coals below the Conglomerate sandstone, long before those above the Conglomerate are reached. There are several of the Sub-conglomerate coals, usually of excellent quality, but, with the exception of one, not often of workable thickness. This coal is fully described by Mr. A. R. Crandall, in his report on the geology of Menifee county.

It is in quality good, but it varies from twenty-two to forty inches in thickness, with an average of perhaps thirty. The area underlaid by it is very large, and it is capable of producing a large amount of coal; but from its thinness and irregularity, it cannot be mined so cheaply as the thicker coals above the Conglomerate. These Sub-conglomerate coals of the Red river, Slate, and Beaver Creek valleys, having been examined and described in the report of Mr. Crandall, no further mention of them will be made here.

The examination for this report began at the top of the Conglomerate, at the head of Chimney Top creek, and extended in a southeasterly direction to the mouth of Troublesome creek.

TOPOGRAPHY.

The country between the Red and Kentucky rivers has its topography determined for the greater portion of its area—all of it, at least, except that near the head of Red river—by the Conglomerate sandstone.

In its western extension, from the Middle Fork of Red river westward, the dividing ridge is narrow, high, and precipitous, as the sandstone, in its resistance to erosion, forms bold and massive cliffs, often extremely picturesque in outline. The ridge grows higher and narrower to the west as the determining rock, the Conglomerate, rises in conformity with the general rise in the rock formations of the country; while to the east, toward the head of Red river, as the Conglomerate descends, and is covered by an increasing thickness of over-

lying shales and shaly sandstones, the surface of the country becomes more even, the hills lower, and with more gentle slopes, while only that portion of the country bordering closely on the main streams shows the cliff topography.

From the head of Middle Fork of Red river eastward, for several miles, the dividing ridge is narrow, and the thickness of rock above the Conglomerate slight. After passing Chimney Top and Lower Devil creeks, the surface of the country becomes more even, the hills low, not usually extending more than one hundred and fifty or two hundred feet above the branches of the main creek, while the slopes of the hills are so gentle that they can be, and in many cases now are, cultivated clear to the tops. It is one of the best agricultural regions in Eastern Kentucky. In the ridge there are numerous low gaps, leading from one stream to another, offering a comparatively easy passage for a railroad line.

The topography is of this character on both sides of the dividing ridge, at and near the heads of Upper Devil, Swift's Camp, Stillwater, and Holly creeks; but along the Red and Kentucky rivers, as well as on the lower part of the creeks just mentioned, the country is still rocky and broken by the Conglomerate cliffs.

As we proceed southeastward from Holly creek, another change takes place in the topography, which is here determined by the alternated coarse and shaly sandstones which occur above the Conglomerate.

After the Conglomerate passes beneath the drainage, there is no one member of the rock series which alone determines the topography. On the contrary, we have the hills, showing the resultant of the different resistance to erosion of massive sandstones and shales or shaly sandstones. The hills rise from four hundred and fifty to six hundred feet above the river, and present a much steeper slope, extending in about the same degree from top to bottom; but when it comes to be examined in detail, it is seen to be made up of a series of terraces, steep, and often precipitous, where the heavy, coarse standstones occur, and more gently sloping over the

shales and shaly sandstones. The coarse sandstones, from the way they resist erosive agencies, are more often exposed than the shaly beds, and they are seen in proportion to their thickness. The shales and shaly sandstones are usually covered by the talus from the overlying coarse sandstones, and good exposures are more rare.

This character of topography begins above the mouth of Holly creek, and extends as far as the field covered by this report. Above Jackson, in the dividing ridge between the river, or the short branches emptying immediately into the river and Cane creek, a heavy sandstone, about fifty feet in thickness, caps the hills, which there rise to a greater height above the river than at any place before noted.

GEOLOGY.

In the description of the topography, or the surface configuration of the country under discussion, the character of the geology has been roughly outlined, for it is the rock structure which determines the contour of the surface of any region, and no intelligible description of the topography can well be made without reference to the determining rocks.

There are in this region only the rocks of the Carboniferous formation. West and northwest, beyond the head of Middle Fork of Red river, are found rocks lower down in the geological series; but, for a description of their position, order, thickness, etc., the reader is referred to the report of Mr. A. R. Crandall, before referred to.

As may be inferred from what has already been said, the Conglomerate sandstone is by far the most prominent member of the rock series of this region, and has exerted a greater influence upon the formation of the topography than any other. It forms the rocky wall which fences in Eastern Kentucky from ready communication with other portions of the State, and, with its frowning cliffs, guards its stores of mineral wealth. It has been the most serious obstacle to the development, both material and social, of Eastern Kentucky,

for it has prevented that necessity of modern civilization, quick and cheap transportation.

From whatever point a railroad is projected to enter Eastern Kentucky, it must encounter the serious difficulty of surmounting the Conglomerate sandstone, if it would penetrate to the heart of the coal fields, where the best and thickest coals are found in such abundance that they can furnish an ample supply for generations to come—a supply upon which can be based permanent mining enterprises.

The Conglomerate is often found in two members, with a series of shales containing coal, between. The lower member is uncertain and irregular, both in occurrence and thickness; but the upper member is present all through this region, although varying somewhat in thickness. It is the most important, and is the one referred to as the Conglomerate. In thickness it is here from one hundred and fifty to two hundred feet. In character it is a coarse, massive sandstone, at places full of pebbles, and usually showing prominent cross-stratification lines. The pebbles are most abundant in the lower part of the sandstone, decreasing towards the top; and as we go to the southeast, where the greater portion of it has passed below the drainage line, and the top only is exposed, they disappear almost altogether; so that it becomes difficult to distinguish the Conglomerate from some other coarse sandstones which occur above it.

The thickness of rock above the Conglomerate at the western end of this section is small, ranging from fifty to one hundred feet, and this only in detached knobs at the heads of the small streams, while out on the points the top of the Conglomerate is often bare. This thickness increases rapidly towards the southeast, until, between Swift's Camp and Upper Devil creeks, in the neighborhood of Campton, it ranges from one hundred and twenty-five to one hundred and seventy-five feet.

In the dividing ridge at the heads of Holly and Stillwater creeks this thickness increases to two hundred feet and more; but along the lower portion of these streams it is usually less.

Above Holly creek the hills rise rapidly to twice their former elevation above the Conglomerate, in consequence of a change in the character of the prevalent rock from shaly to coarse sandstone. At the western end of the section, from the head of the Middle Fork of Red river to Swift's Camp creek, the rocks above the Conglomerate are almost entirely shales or shaly sandstones, wherever seen.

In passing above Swift's Camp creek thicker and coarser sandstones begin to be seen, which increase in frequency until they form the greater portion of the rocks.

The Conglomerate passes beneath the drainage near the mouth of Frozen creek. From this point to the mouth of Troublesome creek, coarse, massive sandstones, ranging from ten to fifty feet in thickness, are the most prominent features in the section. These sandstones are frequently exposed in cliffs on the hillsides; but, with few exceptions, they do not hold their character and position over large areas, as they frequently give place to shaly sandstones and others, which before had been shaly, become coarse and massive.

Of bituminous and clay shales, there is not in this region any great thickness. Occasional outcrops are found, but, in comparison with the great mass of shaly and coarse sandstones, they are rare; nor do they hold any great extent in area; on the contrary, they seem to be quite local, and when the attempt is made to trace them for any distance, they are usually found becoming more and more sandy, until they change insensibly to shaly sandstone.

After passing the Sub-carboniferous limestone, which lies below the Conglomerate, there is no pure limestone of any thickness found in this region. Numerous bands of dark, very silicious limestone or calcareous sandstone are found, but they are usually thin; not in any case more than four feet in thickness. In many places they do not form regular strata, but occur in large lenticular or kidney-shaped masses, lying in sandstone or shale. These kidneys are usually more silicious than the beds or strata of impure limestone. In places, some of these bands of limestone become fossiliferous, but

these cases are exceptional. So far as seen, they do not occur at regular, well-marked intervals, nor do they have any great horizonal range.

The limestones, so pure in quality and so persistent in position, which often serve as guides in the identification of coal seams near the Ohio river, seem to be entirely wanting here, and we have in their places these numerous, erratic, and untrustworthy bands of impure limestone, which are of almost no value whatever for use in geological identification.

The absence of these limestones, and the frequency with which the sandstones and shales change character, render the construction of an accurate section, and the identification of coal seams across any great interval, a matter of considerable difficulty. The absence of limestone and fine shales, as well as the character of the prevailing rock, which is a coarse mechanical sediment for the most part, indicates the prevalence throughout this region, during its deposition, of shallow waters much disturbed by currents, accompanied by frequent changes of level. There was no subsidence deep enough or long enough continued to allow the formation of pure limestones, nor were the waters quiet and land-locked lagoons, in which the fine mud could settle undisturbed, to be afterwards compacted into shale beds.

It is worthy of notice, that the Sub-carboniferous limestone, which in Ohio is thin and frequently wanting altogether, thickens from the Ohio river to the southwestward, while the limestones of the coal measures, several of which are found in Ohio, disappear soon after crossing into Kentucky.

SECTION.

Accompanying this report will be found a horizontal section showing the principal features of the geology, from the dividing ridge west of Campton to the Kentucky river, at the mouth of Troublesome creek. This section is by no means complete, and it is not offered as such. On the contrary, as already stated, it will probably be found to need considerable correction when the country comes to be examined in detail; and it

is not at all impossible that, especially in the southeastern end of the section, some of the connections between the coals may be found to be incorrect. It is believed, however, that the greater portion of the section is correct. The measurements for elevation were made with an aneroid barometer, without any correction from a check barometer, at a time of the year when atmospheric variations are often sudden and great, so that there is a liability to error from this cause. On the other hand, the measurements for level were usually made with the Kentucky river as a base, the level of this being known from actual survey, and the variations were checked as often as possible by returning to the river. The measurements for distance will probably need some correction, as they were not obtained from the most reliable sources, the existing maps of this region being very imperfect. The section is given as the best that could be accomplished with the time and means at command, and it serves very well to show the principal features of the geology of this region.

It will be seen that there is a total thickness of seven hundred and fifty feet of strata above the top of the Conglomerate included in the accompanying section. This, with the three hundred and twenty-five feet of Conglomerate and Sub-conglomerate beds, makes a total thickness of one thousand and seventy-five feet of Carboniferous rocks above the Sub-carboniferous limestone, from the river at the mouth of Troublesome creek to the edge of the coal measures.

COAL.

The coals of this region are numerous and of excellent quality, and, taken as a whole, will bear comparison with those found in any other portion of the State in quality or thickness. They are all classed as bituminous coals; but they show all the varieties of this class, known as dry-burning, caking, and cannel coals. The principal coals are of the dry or free-burning variety, while the caking or fat coals are comparatively rare. Cannel coals are abundant and of excellent quality; certain of them having a reputation second to none in the State.

As yet, this region is almost entirely undeveloped, so that it is difficult or impossible, without the most detailed and careful study, to obtain a complete section, showing the thickness and position of all of the coal seams—a study which has, as yet, not been given to it. There are numerous mines along the Kentucky river, where coal has been mined for shipment in boats down the river; but none of them are extensive, and the majority are now abandoned and have fallen in.

The practice is to open a drift from which a few boat-loads of coal are taken, when, as soon as it is far enough underground to render it a matter of some labor to get the coal to the mouth of the drift, it is abandoned, and another one opened. The so-called mines are, therefore, but a series of shallow pits.

Of late years, owing to the low price of coal in the lower markets, coal mining has not been as profitable as formerly, and but little is now mined in this region, except of the finer grades of cannel coal, which bring a higher price, and can, therefore, yet be mined and transported at a profit.

The cause of this stagnation in the mining industry is the excessive cost of transportation; due entirely to the uncertainty and danger of the river navigation. Coal-boats drawing five feet of water can only be run during high water, which can be expected but for a very small part of the year. This, therefore, necessitates the storage of large quantities of coal, often for months after it is mined, while waiting for a rise in the river sufficient to carry it off. This storage is of great detriment to the coal, as it is injured by exposure to the weather. In addition to the injury and loss by exposure, an extra cost is involved through the loss of capital lying idle for so long a time.

The boats used to carry the coal down the river can never be returned, and they are, therefore, usually sold at a great loss. The river is so difficult of navigation, that from three to five men are required to manage each boat, or one man to about each thousand bushels of coal; the boats usually holding from three to five thousand bushels of coal each.

In addition to these necessary and inevitable expenses, there is great risk involved in the navigation of the river, a large proportion of the boats never reaching their destination.

These combined causes make the cost of coal, at the markets along the lower river, so great, that Pennsylvania coal is brought down the Ohio river, up the Kentucky, and sold at a less price in Frankfort than the coal from this region. Thus, the work which has been done by the State in improving the navigation of the Kentucky river, for a part of its course only, actually operates against the interests of Kentucky coal miners, instead of furthering them, for it enables Pennsylvania coal to compete with them in their own markets, without assisting them in any degree. Were Kentucky river slack-watered to the mines, so that coal could be shipped at nearly all seasons of the year, and the empty barges returned cheaply, this region could supply coal to the whole of that part of the State bordering the river, at prices which would drive all foreign coal from the market; and it could even do a large business on the Ohio river in the fine cannel coals in which it abounds.

Until improved means of transportation are furnished this region, either by slack-water or railroad, there can be no extensive and regularly conducted mining enterprises. The fine-grade cannel coals will probably continue to be mined in a precarious and haphazard way, as they commonly bring a price sufficient to pay a small profit over the risk and expense of transportation; but, with this exception, the great body of coal will remain untouched.

The lowest coal mines on the Kentucky river are near the mouth of the South Fork, at Beattyville and Proctor, where one of the Sub-conglomerate coals of excellent quality is mined. There are few mines above this for about twenty-five to thirty miles along the river, until near the mouth of Holly creek. Between these places the river runs through "the narrows," a gorge or cañon which it has cut through the Conglomerate. For most of this distance the Sub-conglomerate coals are beneath the level of the river, while the hills

do not rise sufficiently high over the Conglomerate, until some distance back from the river, to hold the coals which have been mined further up.

Above Holly creek, banks have been opened every few miles, until the last are reached about five miles above Hazard, in Perry county. Most of these, as already stated, are abandoned, and have fallen in, so that exposures of the coal that can be measured are rare. Back from the river, openings or exposures of the coals are very few, as there has been no inducement to mine coal while wood is still the most common household fuel in use. In studying the geology of this country, therefore, reliance has to be placed mainly on natural exposures or outcrops of coal; so that it is a matter of considerable difficulty to obtain a complete section, showing the position of all the coals.

In the accompanying section the position of the coals shown is well ascertained; but, from the reasons just given, the thickness has not been accurately determined in every case.

The change in the general character of the rocks from that of the region nearer the Ohio river, which has been referred to before, is accompanied, to a certain extent, with a change in the coals; but the region has not yet been examined over a sufficiently large area to enable a generalization as to the number and equivalency of the coal seams. The section bears in its lower part a resemblance to that of the country near the Ohio river; but, after the first two hundred and fifty feet above the Conglomerate is passed, the resemblance is not so great. There seem to be, here, greater changes between coals, within short distances, than are common farther north.

In the section accompanying this report are shown eight coal seams above the Conglomerate. From the detailed vertical sections given in the horizontal section, the evidence upon which this identification is based can be seen. The dotted lines connecting the coals in the section indicate the probable connection between them; but it must be distinctly

understood that this is not positively asserted. It is only the connection which seems the most probable, with our present knowledge.

The first coal of the section, the equivalent of coal No. 1 of the Greenup County section, and of Ohio Geological Reports, occurs from twenty to fifty feet above the top of the Conglomerate. It is first opened near Campton, on Swift's Camp creek, and also on Bear Pen Branch of Upper Devil creek. Its position, here, is about twenty-five feet above the top of the Conglomerate. Its thickness is from twenty-four to thirty inches. It is a fat or caking coal, of very good quality, especially the lower portion of it. In this respect it differs from the No. 1 coal further north, which is there a typical dry-burning or furnace coal. It is the famous Jackson and Briar Hill coal, with which over half of the iron made in Ohio is smelted. The per centage of sulphur present varies considerably, but is usually low. It is seen at a number of places along the river, holding an average thickness of thirty inches. Below the mouth of Frozen creek, near Mr. Nathan Day's, is an old mine, now fallen in, where the coal is said to be thirty-six inches thick in some of the rooms. Below the mouth of Holly creek, on the Holland place, is an exposure where it measured thirty-four inches; but this includes a shale parting of several inches in thickness. On Frozen creek it is seen at a number of places near the mouth, usually about twenty-eight inches thick; but above this stream it has not been seen by the writer. A coal, which is probably this one, is reported on the old Cockrill farm. It probably goes under the river not far above. This coal is an excellent blacksmith fuel, and would doubtless make a firm, hard coke. Coal of this quality is rare in this part of the State, as the majority of the coals are of the soft, free-burning, non-coking character; and although this is thin, it will doubtless eventually become valuable.

The following analyses by Dr. Peter and Mr. Talbutt, show something of the character of this coal in this region:

	1	2
Moisture	3.74	2.50
Volatile combustible matter	35.52	41.10
Fixed carbon	52.64	49.22
Ash	8.10	7.18
Total	100.00	100.00
Coke	60.74	56.40
Sulphur	2.466	0.818
Specific gravity	1.336	1.300

No. 1 is an average sample by Mr. A. R. Crandall, from C. M. Hanks' bank, at Campton, Wolfe county.

No. 2 is an average sample, by the writer, of coal from an opening abqve Wm. Day's, on Frozen creek, Breathitt county.

COAL NO. 2.

About seventy-five feet above the coal just described, has been found at a few places, another coal seam, which is probably the equivalent of coal No. 2 of the Greenup section. Like that, it is usually thin, not having been seen more than twenty inches thick. At other places it is less, not more than twelve inches. It is not mined at any place, and, consequently, no samples were procured for analysis. It is best shown on the branches of Swift's Camp creek, above Campton.

COAL NO. 3.

At a distance ranging from one hundred and forty to one hundred and ninety feet above the Conglomerate is found a coal, which, from its character and position, seems to be the equivalent of coal No. 3 of the Greenup section.

It is better known than any other coal of this region, for the reason that it has been most extensively worked. The mines on the Kentucky river, from Holly to Quicksand creek, are all in this coal, with the single exception of the entry in the No. 1 coal already noted. On this account, also, better opportunities for sampling the coal are given.

From our present knowledge, this coal seems to be one of the most regular and trustworthy of any in this region, which characteristics it holds all through Eastern Kentucky, as far as we now know it. Along the ridge, between the Red and Kentucky rivers, it is first opened at the head of one branch of Upper Devil creek, about four and a half miles from Campton, at the Hobbs bank.

The coal here consists of three members or divisions, separated by thin shale partings. The following is the section of the coal at this place:

Coal	2′	
Shale parting		3″
Coal	1′	8″
Shale parting		8″
Coal	1′	3″

Giving us a total thickness of four feet eleven inches of coal. The quality of the coal here is excellent, as will be shown further along. It is somewhat sulphurous in appearance; but the pyrites is in small flakes, which hardly form an appreciable per centage of the whole. This splendid coal is the first of a thickness greater than three feet, which would be reached by a railroad, after crossing Red river.

On the Kentucky river, the first opening of this coal is at the Holland mine, below the mouth of Holly creek. The coal is here about three feet in thickness, or a little less. Along the river, the thickness varies from three to three and one half feet of coal. The thickness, including parting, is usually much more, as there is commonly a slate parting, which varies from three to twelve inches. This is usually measured with the coal; hence it is commonly called four feet thick.

At the Hobbs bank, this coal is about four hundred feet above the river. It rapidly descends to the southeast, until, at the Holland bank, it is only a little over three hundred feet above. At Jackson it is only one hundred feet, while above this it descends still more rapidly, until, at the mouth of Quicksand creek, it is at the level of low water in the river. From this point to the end of the section the dip changes, and the rocks are horizontal, or nearly so. From some observations

made above the mouth of Troublesome creek, it seems probable that the coal, there, dips in the opposite direction, and that it rises more rapidly than the rise in the level of the river. This conclusion is based upon an identification of a coal on Wolf creek, which is not as yet supported by sufficient stratigraphical evidence to be by any means certain, as the examinations in that region have not yet been detailed. The coal on Wolf creek resembles the No. 3 very closely in physical character and chemical constitution, as will be seen by the analyses appended. It is thicker here than it is known to be at any other locality below. It is reported, on good authority, to be seven feet in thickness. When visited by the writer, the drift had caved in, so that the whole thickness could not be seen; but satisfactory evidence was obtained, by measuring some of the timbers which had been cut to support the roof of the drift, that the coal is more than six feet thick.

Below Jackson, at Spencer's mine, this coal, with a total thickness of about four feet, including partings, shows a little less than three and one half feet of coal. At Cardwell's bank, near Jackson, it is nearly the same. Along the river, opposite and above Jackson, this coal has been mined at many places, none of which are now open, so that it can be examined. It is stated that the shale parting grows gradually thicker and the coal thinner further up stream. This statement is corroborated by the following section, at a natural exposure of the coal in the bank of the river at the mouth of Stray branch:

Coal	1′	9″
Shale parting	1′	8″
Coal		5″
Shale parting		4″
Coal		2″
Shale parting		2″
Coal		1″
Shale parting	1′	2″
Coal		7″

The total thickness of coal in the above section is thirty-six inches; but the numerous thin bands into which it is divided, and the shale partings between, show that at this point, during the formation of the coal, it was subject to frequent fluctua-

tions of level, probably not of any great extent, but sufficient to check the growth of the coal vegetation, and to allow the deposition of layers of mud, which became afterwards hardened into the clay shale partings.

These frequent old openings in this coal, along the river, identify it beyond doubt, and also show the rate of dip.

In character, it is usually a distinctly laminated and dry-burning coal, with considerable fibrous coal or mineral charcoal between the laminæ. At places portions of it are bituminous enough to coke, but this is not its general character.

The amount of sulphur present varies considerably, but is usually low, as is also the ash, while the per centage of fixed carbon is high. These three qualifications render the coal an excellent fuel for general purposes, and when considered in connection with its dry-burning, non-caking character, render it extremely probable that the coal would make a successful furnace fuel for the manufacture of iron.

The following analyses, by Dr. Peter and Mr. Talbutt, show the composition of this coal at several places:

	1	2	3	4
Moisture	3.50	3.56	4.90	2.76
Volatile combustible matters	35.20	33.56	35.30	36.60
Fixed carbon	56.70	58.38	55.50	56.50
Ash	4.60	4.50	4.30	4.06
Total	100.00	100.00	100.00	100.00
Coke	61.30	62.88	59.80	60.56
Sulphur	1.189	1.381	3.153	0.865
Specific gravity	1.294	1.297	1.290	1.290

No. 1 is from the Hobbs' bank, at the head of Upper Devil creek. Average sample by the writer.

No. 2 is from Wm. Spencer's mine on Kentucky river, below Jackson. Average sample by the writer.

No. 3 is from the Holland mine, below the mouth of Holly creek. Sample taken by the writer from a large pile of coal which had lain exposed to the weather for about one year.

No. 4 is from the South mine, on Wolf creek. Average sample by Mr. J. R. Procter and the writer, from a large pile which had also been exposed to the weather for about a year. As already stated, this coal is not positively identified as the same as the others, but for convenience it is given with them. It will be noted that its chemical composition closely resembles the others.

Above coal No. 3 the remaining coals of the section are not so well known, either as to position or character, for the reason that they have not been so extensively mined, and outcrops are comparatively rare. With our present knowledge, the coals above No. 3 seem to be more irregular and uncertain than that one; although it is possible, when they are better known, and a more complete series of sections obtained, that they will be found to be more uniform than is now supposed. For this reason, the attempt will not be made to number and classify them at present. They will be described in their approximate order.

The first workable cannel coals near the line of this section are found above coal No. 3. Such coals occur, at various levels, all through this region; but the lower ones are usually thin.

On the Kentucky river, at a distance varying from thirty to fifty feet above coal No. 3, is found another coal, usually about two feet thick. It is a rather fat, bituminous coal, of very good quality; but it has not been worked. It is seen of this thickness at the Spencer and Cardwell banks, below Jackson. Still further down the river, it is reported to be more than three feet thick, but it was not seen by the writer. Above Jackson this coal is thinner.

At many localities the proper level for this coal is occupied by a shale or sandstone, while at about seventy to eighty feet above Coal No. 3 we find a cannel coal. This is the cannel coal which is seen in the river hill about one mile below Wm. Spencer's. It is not well exposed here, but it seems to be thin. It is probably also the cannel coal seen at G. W. Johnson's, near the head of Nichols Fork of Frozen creek. It is

here seen in outcrop along the hillsides at many places, but has not yet been opened so as to show its full thickness. Blocks of coal nearly two feet in thickness were seen tumbled out on the hillside; but beyond this there was nothing to determine its thickness.

The frequency of outcrop of this coal in this neighborhood shows it to be quite a persistent seam, and it is to be hoped that, when it is opened, it will be found of workable thickness. Two varieties of cannel coal are seen here, both probably from the same bed or seam. One is hard, of very uniform, rather coarse-grained structure, showing perfect conchoidal fracture, and abounding in brilliantly polished surfaces or slickensides, which have probably been caused by faults or slips in the hill squeezing and pressing the coal upon itself. This coal contains a considerable proportion of earthy matter, as will be seen by the analysis further along; and to this cause may possibly be due the readiness with which it assumes a polish.

Fortunately, this variety of the coal seems to be much less abundant than that other, which shows a partly laminated structure, irregular fracture, is of a less homogeneous nature, and not nearly so handsome; but which proves, on analysis, to be one of the best cannel coals of this whole region. It is sometimes called the "curly cannel," owing to its peculiar structure.

The cannel coal which is found at John Murphy's, on Stillwater creek, is probably the equivalent of this seam.

The cannel coal which is mined on Quicksand creek, about one mile above its mouth, is probably also the same. This coal shows a total thickness of twenty-five to twenty-six inches, of which the upper eight inches is bituminous, leaving only a thickness of seventeen to eighteen inches of pure cannel. It has an excellent reputation in the lower markets, and commands a high price; so that, in spite of its being so thin, it is mined at a profit. The analysis of this coal is given further along in this report.

On George's branch, which empties into the Kentucky river several miles above the mouth of Troublesome creek, a cannel coal of excellent quality is mined, which, if the supposition as to the equivalency of the Wolf Creek coal with the No. 3 be correct, is the same coal as that just described on Quicksand creek. This coal shows a total thickness of thirty-four to thirty-six inches, of which twenty-two to twenty-four inches is cannel coal, the remainder bituminous. Like the Quicksand Creek coal, this has an excellent reputation in market, and brings the highest price. It is much sought after by consumers, for household fuel.

The position of this coal at the various localities corresponds very well with that of coal No. 4 of the Greenup County section.

At a distance ranging from sixty to eighty feet above the last described coal another has been seen in imperfect outcrop at a number of places, but it is not mined at any place; so that very little is known of its thickness or quality. The stain, or the weathered outcrop of it, is frequently seen. On a short branch emptying into the Kentucky river from the opposite side, above the mouth of Quicksand creek, this coal is washed bare by the stream, and shows a thickness of thirty inches. It is a bright, glistening, caking coal, of very good quality, as far as could be judged from the limited exposure.

At the Haddock mines, on the bank of the river above Troublesome creek, this coal has been found as a cannel coal, and is reported to be twenty inches thick. The outcrop was not sufficient, when seen by the writer, to prove anything as to its thickness; but it showed the existence of cannel coal at that point.

From one hundred and ten to one hundred and twenty-five feet above this last coal, at a height, where best known, of two hundred and fifty feet above the Kentucky river, is found the most valuable cannel coal of this region. It is commonly known as the Haddock coal, as it is mined most largely at the Haddock mines, at the mouth of Troublesome creek. This is the thickest cannel coal on the line of this section, and in

quality it is equal to any. It does not contain as much volatile combustible matter as some of the other cannel coals, and will not make quite so brilliant a fire, but it contains less ash than the most of the others. It is mined, for this region, in considerable quantities at the Haddock and Sewell mines, near the mouth of Troublesome creek. Here it usually shows a thickness of thirty-four inches of cannel coal, with ten to twelve inches of bituminous coal above. In one of the drifts of the Sewell mines there was seen thirty-six inches of cannel coal, with ten inches of bituminous above; and the miners report that, in some rooms, the cannel coal reaches a thickness of forty-eight inches. The miners "bear in" on the soft bituminous coal above, and then wedge up the cannel coal in large blocks.

This coal is also found on the same side of the river two or three miles below, on land belonging to Wm. Spencer. It has never been mined here, but it shows at an outcrop, imperfectly seen, thirty-four inches thick, and it is reported to be three inches thicker when the whole thickness is exposed. Of this, all but the upper four or five inches is cannel coal. Below this point this coal has not been mined or even opened so as to show its thickness, at any point known to the writer; but it has been found as a stain at some places. It is said to be opened on the east bank of the river a short distance below the mouth of Troublesome creek, but the place has not yet been visited by any member of the Survey. Whether the coal extends down the river, holding its thickness for any distance, is unknown; but from the well-known uncertain character of cannel coal, it is at least doubtful. However, it has been found at enough places, widely separated from each other, to prove that it underlies a large area, sufficiently large to be able to supply all the demands of an extensive mining industry for a long time to come.

In the hill at the Haddock mines, at a distance of one hundred and ten feet above the main cannel coal, a coal has been found, which is reported to be a semi-cannel coal, four feet in thickness; but it had caved in at the time of examination by

the writer, so that nothing could be seen of it. The "stain" or "sign" of this coal was found at other places, enough to show that it holds its position with considerable persistence.

Fifty feet above this coal is found another, which has been mined on the opposite side of the river from the Haddock mines, by Mr. J. Wells. It here shows the following section:

Coal		11 inches.
Shale parting		2 "
Coal	1 foot	1 "
Shale parting		4 "
Coal	1 "	3 "

A total thickness of three feet three inches coal, excluding shale parting. It is a dry-burning, bituminous coal, quite free from sulphur, but carrying a rather large per centage of ash, as shown by the following analysis, by Dr. Peter and Mr. Talbutt, of an average sample taken by the writer. The coal sampled from was near the outcrop, and hence the analysis may possibly show more ash than properly belongs to it:

Moisture	2.78
Volatile combustible matter	35.52
Fixed carbon	44.94
Ash	16.76
Total	100.00
Coke	61.70
Sulphur	1.423
Specific gravity	1.398

This is the highest coal geologically in this region of which anything is definitely known. At several localities a coal stain is found immediately below the massive, heavy sandstone which caps the hills back from the river, but nothing is known as to its character or thickness.

UNDETERMINED COALS.

As the examination made of this region was so largely of the nature of a reconnoissance, many exposures of coal were seen—especially when at some distance to one side of the line of the section—the geological equivalency of which was not determined, owing to lack of time for detailed examination.

The coals on Wolf creek and George's branch should really be classed here, as they are by no means certainly identified.

On main Frozen creek, above the house of Mr. Green Tolby, a coal is found about one hundred and seventy-five feet above the bed of the creek, in natural outcrop below a sandstone cliff, showing a thickness of three feet nine inches clear coal, without any perceptible parting.

On Stillwater and Gilmore creeks, in Wolfe county, cannel coal is found at a number of places, but its equivalency has not yet been determined. At Mr. James F. Ely's, a cannel coal has been opened; but the drift has now fallen in, so that it is partly covered. This is asserted to be three and one half feet in thickness. A thickness of two and one half feet was seen by the writer at an exposure which evidently did not show the whole thickness of the bed. The exposure was such that an average sample for analysis could not be obtained. A hand specimen was, however, subjected to analysis, with the result of showing an excessive per centage of ash. The per centage is so large that it seems possible the specimen selected may have been worse than the average of the coal, although not intentionally selected as such. The general appearance of the coal does not indicate so large a per centage of ash; and it is but justice that this analysis should not be allowed to go unexplained, to the injury of the coal, before an average sample can be selected and analyzed.

On Stillwater creek, at Mr. John W. Faulkner's, a cannel coal is found, which is commonly reported to be three feet thick. Only about ten inches of the upper part of the bed were seen at time of visit, the rest being covered by mud and water. From this also a hand specimen was taken for analysis, which showed a large per centage of ash, not quite so large as in the last case, however. The same caution should be held in regard to this coal as the last; but against it is the fact that it has the reputation, among those who have burned it, of carrying much ash. At John Murphy's, on Stillwater creek, a cannel coal is found outcropping with considerable regularity in the hills back of his house. It has

never been dug into or opened, and nothing is known as to its thickness. It is the coal before referred to as probably the first coal above No. 3.

On Troublesome creek, about fifteen miles from its mouth, below the mouth of Buckhorn creek, on the Roberts farm, is a coal which shows the following section:

Bituminous coal	1′	10″
Shale parting		3″
Bituminous coal	1′	5″
Shale parting		10″
Cannel coal	1′	10″

A total thickness of five feet one inch coal.

There has been considerable excitement in regard to this coal, and very exaggerated reports were in circulation concerning it. The thickness of the whole bed was commonly stated as being cannel coal, when in reality not more than one third of it is of that kind. It is, however, a valuable seam of coal, as it can be mined very cheaply, owing to its thickness. The quality of the different members of this coal is shown by the following analyses, by Dr. Peter and Mr. Talbutt, from average samples taken by myself:

	1	2	3
Moisture	3.30	2.20	3.40
Volatile combustible matter	31.44	39.20	43.40
Fixed carbon	49.76	51.14	46.96
Ash	15.50	7.46	6.24
Total	100.00	100 00	100.00
Coke	65.26	58.60	53.20
Sulphur	.991	2.525	.630
Specific gravity	1.405	1.290	1.280

No. 1 is the upper seam—bituminous.

No. 2 is the middle seam—bituminous.

No. 3 is the bottom seam—cannel.

There is a salt well on the Kentucky river, opposite the mouth of Troublesome creek, which is reported to have passed through four coals in sinking to its present depth of four hundred and ten feet. Measurements of coals by boring

are always liable to error, especially if, as in this case, the boring was not made for the especial purpose of finding coal, but to obtain salt water, as the borings are very apt to become mixed by the drill. It is also difficult to tell the exact line of passage from one stratum of rock to another. The well was sunk in 1846 by Col. L. C. Bohannan. The records of the well have, unfortunately, been lost; but, from memory, Col. Bohannan states the position and thickness of the coals passed through approximately, as follows:

First, about ten feet below the surface a coal, reported two feet six inches thick.

Second, from forty to fifty feet below the surface another coal, reported three feet thick.

Third, about two hundred feet from the surface a coal, said to be about four feet thick.

Fourth, after passing through a very thick, coarse sandstone, a coal was reached at a depth of three hundred and eighty to three hundred and ninety feet from the surface, which is said to be of the unusual thickness of ten feet.

This is probably one of the Sub-conglomerate coals, which at other places is associated with a great thickness of bituminous shale, often mistaken for coal. This is peculiarly liable to be the case when nothing but the finely comminuted fragments of the material from the well can be had for examination. It is hardly probable that the Sub-conglomerate coal, from what we know of it at other places, would thicken so remarkably in this direction. The heavy sandstone reported as having been passed through before reaching the last coal, is very probably the Conglomerate.

The boring is, therefore, interesting, as showing the salt-bearing rock to be either the Conglomerate or the shales below. Nothing definite could be learned as to the amount of brine yielded by this well, or its strength. The prevalent impression in regard to its strength is, that it requires eighty gallons of brine to produce one bushel of salt.

At Mr. Marcum's, above the Haddock mines, two coals have been mined near the river, one of them about seventy-

five feet above the river, and the other about twenty. The upper coal is three feet thick, and is reported to be one of the very best coals mined on the river. The lower was not seen, as it was covered at the time of visit. There is another coal two feet thick above it, separated by about seven feet of space. The upper coal was seen.

At Mr. McIntosh's, about two miles above, a coal about forty feet above the river has been considerably mined, but has now fallen in. This coal was not seen, but was reported to be four feet four inches thick by the former owner.

In addition to the above, numerous exposures of coals too thin for working have been seen, ranging from a few inches in thickness up to two feet. The positions of some of these are known to be in the regular series of the coals, while others seem to be erratic and intercalated seams of no great horizontal range.

QUALITY OF THE CANNEL COALS.

The cannel coals of this region are, for the present, and probably will be for some time to come, more valuable than any other. They will always command a higher price per ton than other coals, on account of their excellent qualities as household fuels and for steam-making. They are also valuable for the manufacture of gas; but their use is limited in this respect, owing to the poor quality of the coke resulting after the volatile portions of the coal have been driven off. The greater thickness and regularity of some of the other coals may eventually, when facilities for transportation become adequate, render them the most valuable, as they can be more cheaply mined than the cannel coals; but the latter, when of good quality and reasonably free from ash, will always be in demand.

As has been already indicated in the descriptions of individual seams, these cannel coals vary greatly in quality as well as thickness, and the same seam often changes thickness and quality very suddenly.

The following analyses, by Dr. Peter and Mr. Talbutt, will serve to show very fairly the different qualities of these coals:

	1	2	3	4	5	6	7
Moisture	1.30	0.94	2.10	1.60	1.20	1.16	1.30
Volatile combustible matter	47.00	52.38	43.10	43.20	58.80	44.58	41.40
Fixed carbon	44.40	35.54	43.36	33.80	35.30	32.76	28.20
Ash	7.30	11.14	11.44	21.40	4.70	21.50	29.10
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Coke	51.70	46.68	54.80	55.20	40.00	54.26	57.30
Sulphur	1.574	1.423	6.119	2.549	.....	0.530	0.846
Specific gravity	1.265	1.280	1.328	1.360	1.180	1.383	1.434

No. 1 is an average sample from the Haddock mine. Sampled from the seam in the mine.

No. 2 from George's branch. Average sample from the stock pile at mouth of pit.

No. 3 from the Quicksand Creek mines. Average sample from the stock pile of coal at the mouth of the pit, taken by Mr. J. R. Procter.

No. 4 is from Frozen creek, near G. W. Johnson's. Sample averaged from a small pile of coal, not more than one or two tons. This is the coal which shows the brilliantly polished faces.

No. 5 from near the same locality. Analysis from a single specimen only. This specimen was not originally selected for analysis, and may, therefore, possibly represent the coal at this place as better than the average.

No. 6 from John W. Faulkner's, Stillwater creek. Analysis from single specimen.

No. 7 from James F. Ely's, Gilmore creek. Analysis from single specimen.

It will be noted that the last three analyses from single specimens show a very small per centage of sulphur, probably considerably less than the average of the coal would show if representative samples were selected. This is liable to be the case when single specimens are used for analysis, as it is very difficult to obtain one which is exactly representative in every respect.

With the exception of Nos. 4, 6, and 7, of which No. 4 is the only average sample, and consequently the only one which should be regarded as good evidence of the quality of the coal, the above analyses show coals of excellent quality, which will compare favorably with the best cannel coals of other localities.

For the purpose of such comparison, the following table of analyses of cannel coals is appended:

	1	2	3	4
Moisture	1.30	1.50	.....	.....
Volatile combustible matter	59.60	52.20	43.37	50.18
Fixed carbon	27.00	40.60	46.50	46.42
Ash	12.10	5.70	10.10	3.40
Total	100.00	100.00	.....	100.00
Coke	39.10	46.30	.....	.....
Sulphur	1.896	0.782	.....	.....
Specific gravity	1.213	1.306	1.27	.....

No. 1 is the well-known Breckinridge cannel coal, Breckinridge county, Kentucky. Analysis by Dr. Peter and Mr. Talbutt. Average sample by Mr. C. J. Norwood.

No. 2 the Hunnewell cannel coal, Greenup county, Kentucky. Analysis by Dr. Peter and Mr. Talbutt.

No. 3 Kanawha cannel coal, below falls of Kanawha Falls, West Virginia. Analysis by U. R. Johnson; copied from his work on coals.

No. 4 the celebrated Wigan cannel coal, from Lancashire, England. Analysis by Heddle.

CONCLUSIONS.

A brief summary of the principal points of economical importance in the foregoing report may not be out of place here.

Of the eight coals above the Conglomerate shown in the accompanying section, five are of workable thickness, considering a coal of two and one half feet as workable. These five coals range in thickness from two and one half to six feet.

Of the three remaining coals: of one nothing is yet known as to its thickness or quality; one is probably too thin to pay for working; while a third has been mined, although only a little over two feet thick. It is reported considerably thicker at other places, and very probably is so; but it cannot be stated positively as such, as it has not been seen by the writer.

Three of these coals are at places cannel coal, two of them workable, both ordinarily of excellent quality. In addition to the coals above the Conglomerate, there is at least one workable coal below, which is of excellent quality and covers a large area.

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Y OF KENTUCKY.

ℓ, DIRECTOR.

ΚAMINATIONS

ATHS OF THE

UNNING RAILWAYS

ENTUCKY.

NORWOOD.

SECOND SERIES.

ARRETT, YEOMAN PRESS, FRANKFORT, KY.

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GEOLOGICAL SURVEY OF KENTUCKY.

N. S. SHALER, DIRECTOR.

A REPORT OF EXAMINATIONS

MADE ALONG THE PATHS OF THE

NORTH AND SOUTH RUNNING RAILWAYS

IN

WESTERN KENTUCKY.

BY CHARLES J. NORWOOD.

PART VII. VOL. IV. SECOND SERIES.

STEREOTYPED FOR THE SURVEY BY MAJOR, JOHNSTON & BARRETT, YEOMAN PRESS, FRANKFORT, KY.

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INTRODUCTORY LETTER.

Professor N. S. SHALER, *Director Kentucky Geological Survey:*

DEAR SIR: I herewith present a report of a reconnoissance made along parts of the lines of the north and south running railways that lie within the western coal field. The report is not so complete as at first might seem desirable; it is believed, however, that it will materially aid future investigations in the regions of which it treats. My acknowledgments are due to Captain R. S. Triplett, of Owensboro', and Hon. John McFarland, of Daviess county; to Mr. W. F. Barclay, of Russellville; Mr. Samuel Gaines, Editor of the Hopkinsville New Era, and Mr. Hunter Wood, of Hopkinsville; Col. Sebree, Mr. J. F. Ford, and Mr. Atkinson, of Earlington; to Mr. William Mills, of Nortonville (who spent a number of days with me), and to Mr. M. H. Crump (now of Paris, Kentucky), for assistance kindly rendered me.

Mr. C. W. Beckham, Aid to the Survey, accompanied me for the purpose of studying the timber and soils adjacent to the railroad lines.

Respectfully,

C. J. NORWOOD.

A REPORT OF EXAMINATIONS MADE ALONG THE PATHS OF THE NORTH AND SOUTH RUNNING RAILWAYS OF WESTERN KENTUCKY.

I.

The results obtained from the examinations conducted along the lines of the north and south running railways of Western Kentucky—namely, the Evansville, Owensboro' and Nashville, and the St. Louis and Southeastern—are, unfortunately, quite imperfect, so far as relates to the details of many parts of the regions through which the roads pass.

The wisdom of having an east and west section constructed as the first work in the field soon became apparent, when work was begun on the north and south running lines. Many points which, by the aid of the east and west section, are now perfectly clear, would have seemed almost hopelessly obscure without the aid of such a section.

Even with the aid of that section, however, there are, as stated above, some parts of the regions in which the succession and conditions of the beds underlying the surface are obscure.

This is largely due to the peculiar geographical features of the regions along the lines of road; the conditions of which are such, that the rock exposures are limited in number, and are frequently far between.

As we recede from the Ohio river we find, in the case of each road, a wide extent of comparatively flat land, which reaches southwardly, from the river, for several miles. On the St. Louis and Southeastern road, this region of comparatively flat land extends southwardly for about seventeen miles—reaching from Henderson nearly to Sebree; on the Evansville, Owensboro' and Nashville road, the larger part

of the distance from Owensboro' to Crow's Station—a distance of nine miles—is comparatively flat land.

Then a succession of low hills and intermediate flat lands—the valleys of nearly all the streams are, for the most part, low flats—are the elements in the topography for several miles towards the south, until we reach what appears to be the great ridge of the coal field. This term, however, is used not so much on account of the actual relative height of the ridge, for this varies considerably in places, but because of its height and linear extent together. It is on this elevation that Madisonville in Hopkins county, and South Carrollton on the Green river, stand; and it seems to be the one which extends through Ohio county, being included between the streams which flow southwardly into the Green river, and those which flow northwardly into Muddy creek. The ridge, as a distinct feature in the geography, seems to be terminated on the east by the waters of Caney creek; but its western termination is not known.

A glance at the map of Kentucky will show that the ridge is cut transversely many times by streams, though not so frequently as shown by the map. Indeed, so far as that alone would show, there does not seem to be any distinct line of elevation extending along the course indicated above, the existence of the ridge only becoming apparent (in the present condition of our maps), upon observations made in the field.*

This ridge, as will become apparent hereafter, is of much importance in both an economic and a scientific point of view, and it is desirable that its form, extent, and structure should be well understood.

After passing over this ridge, we again enter flat land, which seems to be wider in a north and south direction in the west, than in the east; then, within a few miles, we begin to ascend, and soon pass beyond the borders of the coal field.

It will be observed that low lands seem to be the prevailing features in the geography of that part of the coal field crossed by the north and south lines of railroad; and that the courses

* A detailed discussion of this ridge is reserved for a report to be given hereafter.

of the ridges and of the valleys are usually in a west and east direction.

This arrangement of the feature lines is to be referred to two causes; that is, the relative proportions of low and high lands is chiefly dependent on the composition of the underlying beds, while the direction of the ridges is largely due to the condition of the beds.

Along the larger part of the distance traversed by each road, shale beds or very incoherent, easily disintegrated sandstones are the surface beds. As a result, we find extensive "flats" prevailing in those regions that are underlaid by the shales, and the hills low where the sandstones are the first underlying beds. Such hills, besides being low, have another marked characteristic; they are, usually, either flat-topped, set with occasional hillocks (a condition which seems to be due to a mingling of shales and soft sandstones), or their surface is gently undulating, though not infrequently marked with many shallow ravines, which are usually deepest in the sandstones—flattening out in the shale beds.

In no part of the State, perhaps, has the eroding power of water been more effectual in altering the surface features of a region than in the western coal field. No deep gorges are left (though there is no reason to suppose they have not existed for a time), nor are there any high mountains to be seen; but, instead, a great and general leveling has taken place, and is even now in operation, the form of the surface being altered, and the heights lowered rapidly year after year.*

The surface is especially marked by flats towards the Ohio river, along both railroads; so that few or no available rock outcrops are seen in that direction; and even when we come farther south good exposures of the beds are rare. These conditions, taken in connection with the fact that a fault or fold extends across the country in an eastwardly and westwardly direction—the disturbance (although sometimes par-

*The topography of the coal field, and the various details concerning it; the effect of the composition and condition of the beds upon water-courses, etc., is to receive attention in a future report.

tially masked) reaching fully from the east boundary of Ohio county to Sebree, in Webster county, and probably beyond* —show at once the difficulty, if not the impracticability, of constructing a connected geological section from the Ohio river southwardly, without the aid of more complete data than can be obtained by limiting the observations to the narrow strips along these lines of railroad. The most we are able to do is to obtain skeleton sections along these lines, which may be filled in when needed (and any imperfect conclusions modified), as the material is gathered from the more extended surveys that may be made to the east and west of the lines. The plan has accordingly been to delineate, in a simple manner, on the profiles, such outcrops as were found—without attempting to show them continuously connected, except in those places where a perfect familiarity with the relative positions of the beds, or the distinctness of the connection warranted it; and to give a general outline of the economic geology along the lines.

Plates of comparative sections of the beds exposed along the respective roads, and other necessary illustrations, are appended to the report.

II.

THE EVANSVILLE, OWENSBORO', AND NASHVILLE RAILROAD.

At present the rails are laid on this road from Owensboro' only so far as its point of junction with the Elizabethtown and Paducah Railroad (at Owensboro' Junction), a distance of about thirty-six miles.†

The southern extension of the road seems to lie within the limits of the coal measures for the most of its length through Muhlenburg county; and from data obtained from Mr. Barclay, of Russellville, there seem to be outliers on the line in the northern part of Logan county. For the present, only

*This disturbance was more fully studied in Ohio county, and there received the name of the "Rough Creek uplift." I first suspected its existence in 1874, but did not fully determine its general character until the spring of 1876, when the study of Ohio county was undertaken. February, 1877.

†It is understood that arrangements are now in progress for the completion of the road to Nashville. March, 1877.

that part of the line which extends from Owensboro', through Daviess and McLean counties, to Owensboro' Junction, in Muhlenburg county, will be discussed; the intention being to complete the section from Owensboro' Junction to the Logan county line when the survey of Muhlenburg county is completed. At Owensboro' Junction we find what are considered to be the highest workable coals yet found in the western coal field, namely, coals A and B.

One or the other of the coals, usually coal B, is worked in the several mines at the Junction. Coal B has been worked in the Louisville and Stroud City mine, in the Ross mines, and the Galena, formerly known as the St. Louis mine. The coal is reached by shafting at the Galena and the Louisville and Stroud City mine, but at the Ross mines the bed is reached by drifting. These mines were noticed in a former report.*

Following are analyses of averaged samples of coal B collected at the several banks:

Composition.	1	2	3
Moisture	4.16	3.36	5.40
Volatile combustible matter	37.44	37.90	34.20
Fixed carbon	49.80	52.74	54.20
Ash	8.60	6.00	6.20
Total	100.00	100.00	100.00
Sulphur	2.727	2.686	3.136
Specific gravity	1.407	1.309	1.235

No. 1 is from the upper member of the bed at the Ross mines.

No. 2 is an analysis of the bed at the Louisville and Stroud City shaft.

No. 3 is the analysis of samples collected from the Galena mine.

*See report on the geology along the line of the Louisville, Paducah, and Southwestern Railway, part VI, volume I, second series Kentucky Geological Reports, N. S. Shaler, Director.

The upper sixteen inches of the bed at the Junction is known as the "gas coal." Following are analyses of samples collected from (*a*) the Galena shaft and (*b*) the Louisville and Stroud City mines:

Composition.	*a*	*b*
Moisture	4.60	4.60
Volatile combustible matter	37.60	42.60
Fixed carbon	52.64	50.06
Ash	5.16	2.74
Total	100.00	100.00
Sulphur	2.372	1.601
Specific gravity	1.307	1.280

Coal B is about on the level, or a short distance below the level of the railroad at Owensboro Junction, and dips towards the northwest.

As stated in a former report, Owensboro' Junction seems to lie within a geological depression, the beds rising southwardly, westwardly, and somewhat eastwardly; but dipping northwardly. In the cutting just north of the crossing of the Elizabethtown and Paducah Railroad, ten feet of the sandstone which overlies coals A and B is exposed, the base of the bed not being visible. Towards the visible base there is a conglomerated band of ferruginous concretions; and in the parts near this ferruginous band, small quartz pebbles, usually not larger than small shot, are found.

This sandstone, and the beds of shale associated with it, are exposed in the cuts, and in the small elevations near the railroad, for nearly three quarters of a mile, towards the north; there being, however, apparently, a general sinking of the beds in that direction.

About one quarter of a mile northwardly, beyond the Junction, the South Carrollton road crosses the railroad, and mounts a ridge which extends for the larger part of the way to South Carrollton.

At the point where the wagon road crosses, just east of the railroad, sandstone equivalent, in part, to that seen at Owensboro' Junction is exposed. In some of its parts it is extremely coarse-grained and conglomerated—the pebbles being of quartz; they are small, however, and are sparingly distributed through the rock, which is incoherent and ferruginous brown in color. Within a short distance from this exposure, on a higher part of the ridge, at the base of which the sandstone crops out, other beds are exposed, as shown in the following section:

1.	Variegated Sandstone—colors, brown, pink, and yellow. The rock is soft and incoherent	20 feet.
2.	Space	50 "
3.	Coal has been opened, but is now covered; thickness unknown.	
4.	Space	40 "
5.	Brown, disintegrating Sandstone, somewhat of a conglomerate. Full thickness not seen	10 "
	Total	120 "

This is down to the bed of the railroad. Still other beds are exposed in the ridge as it extends towards South Carrollton, and will be noticed on a succeeding page.

Between the fourth and fifth railroad cuts, north of Owensboro' Junction, about three thousand feet northwardly from the wagon road crossing, a shaft was sunk sixty feet in depth, and coal obtained. Some time prior to these examinations the shaft had been abandoned; but some of the material in the heap of debris, near the mouth of the pit, was yet in a fair state for examination: fragments of limestone containing *Martinia* (*lineatus?*) *Athyris subtilita* and Crinoid columns were found. It is stated that coals A and B were both penetrated in the shaft in this order:

1.	Coal A	4½ feet.
2.	Limestone	4½ "
3.	Coal B	5½ "

No opportunity has been found for verifying the thickness given for the beds. This shaft was sunk, it is believed, under the direction of Mr. Throckmorton.

Passing on to the north from this shaft, the beds are found to continue their downward descent towards the north.

At H. D. Rothrock's mine, about half a mile northwardly from Throckmorton's shaft, the coals A and B are found at a depth of one hundred and five feet below the bed of the railroad, which has descended about seven feet of vertical distance from Throckmorton's shaft. This mine is about midway between Owensboro' Junction and South Carrollton.*

A section of the strata at this mine is quite interesting, as we have here the first plain section of the beds above coal A, in which a higher coal is shown.

The following is the record of the materials penetrated in the shaft, as furnished by the manager:

1. Earth, etc.	15	feet.	
2. Sand rock	3 to 4	"	
3. "Soap-stone" (argillaceous and sandy shales?)	50	"	
4. Coal	1	"	8 inches.
5. "Soap-stone" (sandy shale?)	35	"	
6. Coal A	5	"	6 "
7. Under clay	2	"	
8. Limestone	3 feet to 3	"	6 "
9. Coal B	4	"	

Both of the coal beds were worked, but the lower bed, coal B, was the one most largely wrought. The upper sixteen inches of coal B was known at this mine, as at those at Owensboro' Junction, as the "gas coal," a name which appearances would seem to justify. It is a remarkably fine coal for general purposes; and should it prove useful for gas-making, it may be mined and shipped distinct from the other parts of the bed with profit.

The following is an analysis of averaged samples collected from coal B, the "working bed:"

Moisture	3.80
Volatile combustible matters	36.20
Fixed carbon	51.80
Ash	8.20
Total	100.00
Sulphur	3.194
Specific gravity	1.332

*A fire occurred at this mine subsequent to these examinations, and since then it has not been in operation.

From Rothrock's mine to South Carrollton we find occasional outcrops of the beds which overlie the coals at that mine. In the bluffs facing Green river, at South Carrollton, a fine section of the upper beds is exposed. A thickness of at least one hundred and twenty-five feet of beds is found in the river bluff, which, added to that found in Rothrock's shaft, at the foot of the bluff, gives a thickness of about one hundred and eighty feet of beds which overlie coal A at that point.

The following is the section exposed in the bluff near Rothrock's mine, which is about half a mile below (northwestwardly) South Carrollton:

1.	Space from hill top, about	30	feet.		
2.	Black and chocolate colored Bituminous Slate; the upper two inches is soft and smutty			10	inches.
3.	Dark bluish argillaceous Shale	10	"		
4.	Dark argillaceous Shale and thin laminæ of Coal; may be termed an argillaceous coal—very poor—the earthy matter predominating			6	"
5.	Clay and Shale; the upper two feet is mostly clay, and the lower part mostly argillo-sandy shale, greenish drab in color. In the clay under the coal (No. 4) irregular pieces of light blue clayey limestone, apparently somewhat pyritiferous, are found. The rock seems to be local in its nature, and is somewhat concretionary	5	"		
6.	Massive Sandstone	30	"		
7.	Black argillaceous, carbonaceous Shale	1	"		
8.	Black bituminous Slate, with thin seams of clay	1	"		
9.	Coal, separated from No. 8 by two inches of clay	1	"	1	"
10.	Variegated Shales (mostly greenish) and thin sandstones	50	"		
11.	Limestone—the "South Carrollton Limestone"	3 to 10	"		
12.	Space, probably filled with Shale	15	"		
13.	Sandstone. This is usually an admirable building stone, and is quarried for such purposes in the vicinity of South Carrollton; it seems, however, to pass into shaly or thin-bedded sandstone at some places	25	"		
14.	Shale—sandy and bluish-grey in color	10	"		
15.	Coal	1	"	8	"
16.	Sandstone	20	"		
17.	Argillaceous (?) Shale	11	"		
18.	Shale and thin streaks of Coal. This is known among the miners as the "wild" coal	1	"	2	"
19.	Coal	from 6½ to 6	"	2	"
20.	Under clay	4	"		
21.	Limestone; base not seen	1	"	6	"

The beds from No. 1 to No. 14 are exposed in the bluff facing the river; the underlying beds are to be seen in Rothrock's shaft, at the base of the bluff. The section is a very plain one, the succession of the beds, from the top of the hill to the base of the coal shaft, being quite distinct.

The Sandstone, No. 6 of the section, is peculiar in some of its features. It is much cross-laminated towards the bottom;

and, near the bottom, frequently immediately above the black carbonaceous shale (No. 7), conglomerated bands of sand and ferruginous nodules occur. The exterior of the ferruginous nodules is frequently red (due to oxidation), and where the sandstone is thinly bedded or incoherent, it is much stained from them. Knife edges of coal are also not infrequent in the lower part of the sandstone. The physical character of the sandstone seems to be variable; varying from a massive bed to thin or shaly beds, and from a hard, compact rock to a soft, incoherent one.

The Limestone, No. 11, which, for convenience, has been termed the "South Carrollton Limestone," varies in thickness and character; its average thickness may be about six feet. It is somewhat mottled, having somewhat of a ferruginous exterior, marked with dove, drab, or ashy white splotches; upon its fractured surface the rock seems to be mainly blue or dove-colored, changing at some places to drab or chocolate brown. In the vicinity of South Carrollton the surface of the limestone is usually thickly studded with large *crinoid columns;* other fossils seem to be comparatively rare. *Productus splendens*, *Athyris subtilita*, and an occasional gasteropod, were found. Immediately at the town the limestone undergoes a curious modification in thickness. By the road leading down to the ferry it is found as a massive bed, showing a thickness of about four and one half or five feet; but at the large spring, only a few yards away, the thickness is swelled to nearly thirteen feet. At the spring the lower ten feet seems to be massive; but the upper part is a breccia of sandstone and limestone.

This bed seems to be quite trustworthy as a source of water supply; springs are usually found issuing from beneath it.

This limestone was first noticed on the road to Owensboro' Junction, at a point about two or perhaps two and a half miles (by road) from South Carrollton, its position there being about thirty-seven feet higher than at South Carrollton, and about fifty-seven feet higher than in the river bluff near Roth-

rock's mine; the northwardly dip of the rocks is thus plainly shown.

When the first examinations were made in the locality of South Carrollton, this limestone was referred (although with some doubt) to the one which usually separates coals A and B; but the evidence is now pretty plain that it occupies a position about eighty feet above coal A, there being little doubt that the coal wrought at Rothrock's mine, below the town, is to be referred to that number. The order in the beds at this mine, and in the shaft on the railroad (see page 11), is nearly the same: in each shaft a coal of twenty inches in thickness is found, at from thirty to forty feet above the ones below. It is true that only one coal below the coal of twenty inches thickness has been found in the South Carrollton shaft; but there is no reason, as yet, to believe it will not be found. So far, the shaft has been sunk only four feet below the coal, a limestone being encountered at that depth which has not yet been passed through.

The coal at the South Carrollton mine seems to have a considerable amount of pyrites distributed through it in lumps and bands; these are probably partially cleaned from the coal as it is mined. The upper three feet of the bed is considered the best; no analyses have yet been made of it. The bed is about twenty feet, or perhaps a little more, below the level of the water in the Green river, when at its ordinary stage. The bed worked at Kincheloe's bluff (or Lewisport, as it is on the map) is evidently identical with the "working bed" at the Rothrock mine. Its physical characters seem to be the same, and, so far as shown by long measurements, its position below the South Carrollton limestone agrees with that of the South Carrollton bed. The coal was examined, though rather imperfectly, at two places, as the drifts could not be entered for any considerable distance at that time. The section at the mouth of the drift now working is as follows:

1. Massive Sandstone, about	20	feet.
2. Coal and fragile Slate, and threads of clay, in alternating layers.	1	"
3. Coal, with thin seams of clay	2	"
4. Clay seam		½ inch.
5. Coal	3 "	11 "

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At an abandoned drift, a few yards down the river from the above described one, the coal occupies a position about ten feet lower than at the first bank. The same arrangement of the parts of the bed occurs, thus:

1. Sandstone.		
2. Clay shale and coal.		
3. Coal	2 feet.	
4. Clay	½ to ¾ inch.	
5. Coal	3(?) "	

The beds below the coal were not seen.

From South Carrollton towards Livermore the northwardly inclination of the strata seems to continue for at least three miles, and then, at some point beyond that, to rise towards the north; the precise limit of the northwardly dip, however, is obscure. The materials exposed in the railroad cuts within that distance consist chiefly of sandstones and shales. In the first few cuts beyond South Carrollton a bituminous shale, underlaid by coal, is occasionally exposed. The last exposures are seen in the tenth and eleventh cuts northwardly from the town—a distance of about five and a quarter miles from the station.

The section in the tenth cut is as follows:

1. Soft, disintegrating Sandstone, about	15 feet.	
2. Jointed blue Shale	0 to 2 "	
3. Dark argillo-bituminous Shale; hard and somewhat slabby	1 " 6 inches.	
4. Coal	1 foot to 1 " 6 "	
5. Under clay	1 "	

In the eleventh cut the section is very little modified; the coal, however, is about eight feet above the railroad bed, which is descending towards the north, and argillaceous shale is exposed beneath the under clay.

From this cut northwardly the road descends irregularly, sometimes rising, sometimes descending, and reaches a wide area of flat land at about three miles from South Carrollton. Just before entering the principal "flat," however, the road cuts through a low, rather flat-topped elevation, and exposes limestone; this is at a point about four miles from South Carrollton. The limestone is filled with *Martinia plano-convexus*, and contains *Athyris subtilita* and *Martinia perplexus?* The precise relative position of this bed is conjectural; the expos-

ure is very limited; the base is not exposed, and the outcrop is limited to a horizontal distance of only a few yards. The bed is exposed in the middle of the cut, and is concealed, apparently cut off, by quaternary deposits towards the north and south. It somewhat resembles the limestone which separates coals A and B, but it may be equivalent to the "South Carrollton Limestone."

Beyond this cut we descend towards low ground, and soon enter a swampy, densely-timbered flat, which is about a mile wide. This is known as the "Thoroughfare." There is little doubt that this Thoroughfare was at one time the channel for the Green river, or of some large stream which emptied into the river. About midway across the flat the road cuts through a low gravel ridge.

Beyond the Thoroughfare the ground sweeps gently upward and forms a low irregularly-topped ridge, known as the "Island." Island Station stands about midway across the ridge.

In the first cut made by the railroad as it ascends from the Thoroughfare a coal seam 20 inches thick is exposed, as shown in the following section:

1. Soft Sandstone.				
2. Shale			3 feet.	
3. Coal, divided thus:				
a. Coal	10 inches.			
b. Clay	1 "			
c. Coal	8 "	Coal,	1 "	8 inches.
d. Clay	½ "			
e. Coal	2 "			
4. Under clay and Shale to railroad			6 "	

Northwardly from this cut, at about three quarters of a mile southwardly from Island Station, the road exposes two coal stains, which probably represent coals A and B. They are separated by 18 inches to 3 feet of limestone, and are respectively 12 and 6 inches thick. The following section shows the arrangement of the beds:

1. Clay, etc., mostly quaternary deposits.		
2. Coal stain of Coal A? about	1 foot.	
3. Clay		6 inches.
4. Limestone, filled with *Martinia plano-convexus*, 18 inches to	3 "	
5. Coal stain of Coal B?		6 "
6. Clay and Shale	7 "	

It is possible that one of these coals is equivalent to that seen in the cut to the south; but this is only conjectural. The beds seem to be rising to the north, so that the 20 inches of coal seen in that cut may be above the ones at this place.

In the cut just north of the depot at Island Station, nodules of limestone, probably equivalent to the limestone described above, are exposed in the upper part of the cut, underlaid by sandy shale and sandstone.

From this point the road descends to the north for about three quarters of a mile to a flat, which is about half a mile wide. Sandstones and sandy shales, which underlie the beds seen at Island Station, are occasionally exposed in the railroad cuts from the station to the flat. This flat is probably a part of the Green river flat, but is partially separated from it by a narrow, somewhat peculiar ridge. The rise of the hill from the low land is rather gentle up to about sixty feet of height; but from that point up the sides are formed by vertical faces of sandstone. The sandstone presents a curious feature towards the base. At the base it is very calcareous, and quite ferruginous, and in some places a conglomerate of sandstone and limestone. The larger part of the lower 5 feet of the rock seems to be a coarse conglomerate, consisting of fragments of limestone, *Crinoid* columns, the coral *Chætetes milleporaceus*, chert pebbles, sandstone, and broken remains of plants.

The ridge courses south 75° east, and probably extends to the Green river.

The Green river flat begins at the base of this ridge and extends along the railroad to Livermore, a distance of about a mile and a half.

Generalizing from the foregoing notes, it may be stated that, from South Carrollton northward for about five miles, the beds seem to fall northwardly or northwestwardly, and belong to the upper part of the section at South Carrollton. They then rise to the north, the upward sweep being sufficient to bring up the beds associated with coals A and B in the vicinity of Island Station, and the underlying beds ap-

proach the surface as far north as the Green river flat, at which point the outcrops are cut off.

At Livermore a shaft was sunk 27 feet in depth in search of coal. A coal bed is said to have been penetrated at 20 feet below the surface. At present the pit is filled with water. The débris found at the mouth of the pit would seem to show the materials which were penetrated to have consisted chiefly of a thin-bedded or shaly grey sandstone. A few concretionary nodules of iron-stone were observed in the heap; but they appeared to be of poor quality.

The mouth of the pit is about level with the railroad bed just north of the Green river bridge. It is probable that the coal which was penetrated in the shaft corresponds to one which is exposed on the bank of the river, just above the bridge. A coal 18 inches thick is exposed there, at about 14 feet above low-water mark, and about 12 feet below high-water mark. The bed is covered by about 20 inches of bituminous slate. Sandy shale and shaly sandstone fill the space from the coal to the water line of the Green river. This coal is evidently below any of the beds exposed between South Carrollton and Livermore; but its precise place in the order of the beds is conjectural. It may possibly be coal E, but the evidence concerning it is not at all plain.

A red, ferruginous material is found below the coal, at some points on the bank of the river, which may possibly serve for paint; it has never been tried. This material seems to be chiefly clay, which is thoroughly impregnated with iron, the source of which is in the coal bed.

From Livermore to Tichenor's Station, a distance of three miles, the surface is mostly flat, varied by a few low hills, near the line of the railroad. Accordingly there are very few rock exposures in that distance. There is little doubt that the westward extension of the Rough Creek uplift of Ohio county crosses the path of the railroad somewhere in the region of Livermore, either north or south of the town. The probabilities seem to be that the point lies somewhere between Tichenor's Station (or near the station) and Livermore;

but so far the facts concerning it are obscure. It is possible that the line of the disturbance is located between Tichenor's Station and Riley's Station.

Several localities were examined between Livermore and Riley's Station, but very little information was gained concerning the structure of the section between those points.

On the old "Moses Iglehart farm," about two miles a little north of east from Livermore, a coal stain makes its appearance on the hillside, near the dwelling. When first visited, this was supposed to be the outcropping of a bed of some importance, but subsequent examinations have not verified the conjecture. A carbonate iron ore, however, which lies about four feet below the coal stain, has a very fair appearance and may prove to be of value. This can only be proved, however, by a more extended digging than has yet been done, to determine its area, and by chemical analysis to test its purity. The bed ranges from 6 to 9 inches in thickness. It is especially desirable, in order to judge of the value of this ore, to become fully acquainted with its horizontal extent and physical changes, as in some places it seems to pass into a ferruginous limestone, which is of no value as an iron ore. Immediately under the iron ore, and sometimes merging into it at the top, a bed of limestone about 9 inches thick occurs. It weathers with a yellowish surface marked with white splotches. The surface is also marked by drab lumps, which are spread over it. The rock seems to be nearly bare of organic remains; a few small fragments of *Crinoid* columns and a small *Martinia plano-convexus?* were found.

On Mr. Timor Howard's farm, near Mr. John Jones' place, which is about four miles northeastwardly from Riley's Station, a deposit of black slate occurs, moderately rich in bituminous elements and cannel coal-like in structure. This deposit is known in the neighborhood as cannel coal; but it approaches more nearly to cannel slate in its physical characters. The following is the section as exposed in the summer of 1875:

1. Black bituminous Slate, resembling cannel slate	4 feet.	
2. Feriferous layer	1 "	
3. Cannel (?) Slate	2 "	
4. Feriferous layer	1 "	2 inches.

On Mr. John Jones' land, near his dwelling, a limestone holding considerable bitumen (in cavities) is exposed. In appearance the limestone resembles some of the Sub-carboniferous beds, but its identity could not be proved. The presence of bitumen in the rock has caused some to have faith in the existence of a profitable quantity of petroleum on the farm. There does not seem to be, in fact, however, any evidence to justify such a belief. There were some unsuccessful borings made for salt on the place several years ago. Sandy shale was penetrated to some depth (which was not very considerable, however); but, so far as can be gathered, the boring was without important result of any kind.

A few feet above the limestone a coal dirt 2 feet thick is exposed on the hillside, and is overlaid by ochreous sandy shale. This coal has been worked near Mr. Jones', and is reported to measure 3 feet in thickness when well opened.

On Mr. T. B. Bratcher's place, near Mr. Jones', about two and a half miles east of Tichenor's Station, limestone is again found, which may be equivalent to that seen at Mr. Jones', although topographically nearly 130 feet above it. As is the case with the limestone seen at Mr. Jones', fossils are quite rare in the rock, and only a few *Crinoid* columns were found. At about 15 feet above the limestone, at Mr. Bratcher's spring, an inch or two of coal has been found. Fragments of pebbly sandstone are strewn over the slope of the hill.

The outcrop of limestone on Mr. Bratcher's place is about two miles west from the Barrett's Creek salt wells, in Ohio county, at which point the Rough Creek uplift is plainly visible, the Chester beds being brought to the surface there and tilted at high angles.

About one mile eastwardly from Tichenor's Station a coal bed has been opened by Mr. William Atherton. The bed is nearly 3½ feet thick; but, so far as proven in 1875, was not of excellent quality. From the positions of the poorer

portions of the bed, however, it is presumable that, when followed further under the hill, beyond the reach of the atmospheric agencies, the coal may gain considerably in quality.

A few outcrops were seen in other localities between Livermore and Riley's Station, a distance of six miles by the railroad, but very little could be determined concerning them.

From Riley's Station to Lewis' Station there are few outcrops; but the surface is less flat than towards Livermore.

Within a mile of Lewis' Station the cuts begin to show sandstone and shale.

In the cuts just south of the 12th mile-post (numbering from Owensboro') a total thickness of 25 feet of sandstone is exposed. This overlies a coal which has been opened near the road, on land belonging either to Mr. Field or Mr. Vanarsdal. The bed is reported to be 3 feet thick. It is covered by bituminous slate, which appears to be sufficiently dense to form a good roof for mining under.

The position of the coal is about ten feet below the railroad at the 12th mile-post. The ground immediately at the present place of opening is not suitable for mining on a large scale, because of the short depth of the coal below the surface. "Stripping" seems to be the only convenient means by which the coal may be reached. At the hills, however, where the overlying sandstone is present, it is possible for the coal to be worked with more profit.

An outcropping of the western extension of the bed is found on Mr. George N. McKay's land, about west of the 12th mile-post. Mr. McKay did a little digging in the coal, in a small branch. He estimates the thickness of the bed at 3 feet 10 inches to 4 feet 4 inches. The quality and general character of the coal has not been proved, no opening being in a suitable condition for sampling the bed or for studying it sufficiently. From Lewis' Station to Crow's Station—a distance of 3 miles—a few low hills are seen, but the outcrops are few.

At Dr. Hickman's, just south of the 9th mile-post from Owensboro', the cuts expose about 20 feet of sandstone.

Below the sandstone, with shale (?) between, a thin coal is exposed, not exceeding 16 inches in thickness. It is covered by 21 inches of bituminous slate.

A number of springs issue from beneath this coal bed, and have a considerable local reputation, the place serving, in a modest way, as a watering-place for the people of Owensboro'. The waters are chiefly chalybeate. Two or three of them contain alum, however—one of them being somewhat remarkable for the amount of this material it contains.

Following are analyses, made by the chemists of the Survey, of the waters of the springs.*

The following analyses show the composition of the alum waters:

IN 1000. PARTS.

Number of the spring	1	2	6
Basic iron persulphate	0.8756	0.0484	0.1460
Alumina sulphate	1.2468	.3303	.3500
Manganese sulphate	.0032	.0102	.0721
Lime sulphate	.5996	.3947	.3271
Magnesia sulphate	.3330	.3315	.2513
Potash sulphate	.0005	.0068	.0074
Soda sulphate	.0724	.2959	.....
Copper sulphate	.0009	.....	.....
Sodium chloride	.0031	.0127	.0651
Lithia	trace.	trace.	trace.
Silica	.0013	.0014	.0022
Organic matters and loss	.....	.0279	.1877
Total saline matters, dried at 212° F.	3.1364	1.4598	1.4090
Specific gravity	1.00304	1.00164	1.00162

In the water of spring No. 1, it will be noticed, a small amount of copper was found; the amount is so small, however, that it will not seriously affect the influence of the waters.†

*The waters were collected in glass jars and forwarded to the laboratory for examination; but, in spite of all precautions, had lost some of their carbonic acid gas by the time they reached Lexington.

† For further discussion of the properties of these waters, see the chemical report of Dr. Robert Peter in this volume.

The following are analyses of the chalybeate waters:

IN 1000. PARTS.

Number of spring	3	4	5
Iron and manganese oxides	traces.	0.0004	0.0018
Lime carbonate	.1106	.1196	.0256
Magnesia carbonate	.0196	.0331	.0211
Lime sulphate	.1306	.0838	.1379
Magnesia sulphate	.1594	.1057	.0651
Potash sulphate	.0035	.0129	.0103
Soda sulphate	.4567	.5019	.2082
Sodium chloride	.0809	.0213	.0127
Lithia	traces.	traces.	traces.
Copper	.....	.....	trace.
Silica	.0174	.0254	.0298
Organic matters and loss	.0373	.....	.0357
Total saline matters	1.0160	0.9041	0.5482
Specific gravity	1.00115	1.00120	1.00086

No. 3 is the "Sulphur" spring; No. 4, the "Brick" spring, and No. 5, the "Yellow" spring. These springs have been described by the writer in the Owensboro *Shield*, and more extended suggestions made as to the use of the waters.

It seems proper to insert at this place an analysis of the water of the chalybeate spring near Lewis. The spring is but a short ride from Dr. Hickman's, and will doubtlessly prove useful in connection with the springs on his place.

The water from this spring was collected by Captain R. S. Triplett.

COMPOSITION OF 1000. PARTS.

Lime carbonate	0.1155	Held in solution by carbonic acid and precipitated on boiling.
Magnesia carbonate	.0046	
Iron carbonate	.0229	
Alumina	.0027	
Phosphoric acid	.0004	
Silica	.0107	
Lime sulphate	.0204	
Magnesia sulphate	.0768	
Potash sulphate	.0403	
Soda sulphate	.0476	
Sodium chloride	.0146	
Lithium chloride	.0013	
Silica, etc.	.0143	
Total saline matters	0.3720	Dried at 212° F.

From Crow's Station to Owensboro' flats are the prevailing features, the "Black" and "Panther Creek" flats filling the larger part of the distance.

In the vicinity of Owensboro' several coal mines have been opened, all of which are probably in coal D. Two miles and a half below Owensboro', at the site of the old Coal Haven factory, 18 inches of coal is exposed in the bank of the Ohio river. This is mentioned on page 152, volume I, of the old series of Kentucky Geological Reports.

The following section was made at this place:

1. Thin-bedded Sandstone	5 feet or more.		
2. Sandy thinly-laminated Shale, about	10 "		
3. Earthy, pyritous, somewhat lumpy, and calcareous band. Abounds in *Crinoidal* columns and contains *Spirifer cameratus*, *Athyris subtilita*, *Nautilus decoratus?* long slender univalves, *Bellerophon montfortianus*, and *Lophophyllum proliferum*; about			2 inches.
4. Dark Shale, passing below into dense Black Slate	3 "		
5. Coal; said to be	1 "		8 "

At the time this place was visited the coal was covered by the water of the Ohio river. In the hills back from the river coal D has been worked.

Near the old Bon Harbor mines (which are no longer in operation) Mace (?), Shafer & Co. were mining at Barrett's (?) new bank. The coal measures 4 feet 4 inches to 4 feet 10 inches in thickness, and is covered by dense, hard slate. The position of the coal is about 120 feet above the one exposed at the river, though it may be somewhat less. The upper 14 inches of the bed is said to be the best. The following is an analysis of averaged samples of the coal:

Moisture	5.80
Volatile combustible matter	35.06
Fixed carbon	50.40
Ash	8.74
Total	100.00
Sulphur	3.985
Specific gravity	1.318

The same bed is worked at Mr. S. M. Dean's mine, which is about one mile and a half below Owensboro'. At this bank

the coal measures 4 feet 4 inches in thickness. The following is an analysis of averaged samples of the coal:

Moisture	5.12
Volatile combustible matter	34.72
Fixed carbon	51.44
Ash	8.72
Total	100.00
Sulphur	3.513
Specific gravity	1.337

At the "Dutch" mine, about one mile and a half above Owensboro', the coal worked varies from 3½ to 3 feet 2 inches in thickness. The following analysis shows the quality of the coal to be quite fair:

Moisture	4.10
Volatile combustible matter	38.50
Fixed carbon	51.00
Ash	6.40
Total	100.00
Sulphur	1.538
Specific gravity	1.340

At the "Montgomery" mine, near the one mentioned above, the same coal is worked, and measures 3 feet 2 inches in thickness. The following is an analysis of the coal:

Moisture	6.20
Volatile combustible matter	36.20
Fixed carbon	50.90
Ash	6.70
Total	100.00
Sulphur	1.323
Specific gravity	1.323

It will be observed that the per centage of sulphur, so far as indicated by the analysis, is comparatively quite low in this bed. It is probable that the coal worked here is an extension

of the bed worked below Owensboro'; but the wide differences to be observed between the analyses of the samples collected at the mines below the town and of those collected here would seem to indicate a possibility of their being distinct beds. The determination of their exact relations is accordingly left for future consideration.

A coal seam 20 inches thick is reported to have been found at 90 feet below the one wrought at these mines.

III.

THE ST. LOUIS AND SOUTHEASTERN RAILROAD.

The path of this road extends through the counties of Henderson, Webster, Hopkins, and Christian. The larger part of its distance lies within the coal measures, but in the southern part of Christian county Sub-carboniferous beds make their appearance.

As stated on preceding pages, a region of comparatively flat land extends from Henderson, on the Ohio river, southwardly nearly to Sebree, a distance of seventeen miles; and few available outcrops are seen.

At Henderson quaternary deposits conceal the other beds.

The following are records of borings made within the vicinity of the town, published in the reports of the former Geological Survey. At present they are the most that can be given concerning the structure of the section about Henderson, and are presented only as extracts from another report:*

SECTION SHOWING THE COALS FOUND IN THE HENDERSON SHAFT.

1.	Space from top of the shaft to level of high water in the Ohio river	20	feet.		
2.	Space from level of high water	40	"		
3.	Coal	1	"	8	inches.
4.	Space	20	"		
5.	Coal	2	"	4	"
6.	Space	111	"		
7.	Coal	4	"		
8.	Space	88	"		
9.	Coal	3	"	6	"
10.	Space	184	"		
11.	Coal	5	"		

No. 11 of the section was reached, it will be observed, at a total depth of 474 feet below the top of the shaft.

* See volume I, Kentucky Geological Survey, old series, D. D. Owen, Director.

A greater depth was reached, and a larger number of coal beds reported, in a boring made by Mr. Holloway at a point five miles from the Ohio river; but a record of the boring would serve for but little at this place. It is the intention to give, at some future time, the record of this boring, compared with sections obtained elsewhere.

The foregoing section is given merely to show what has been done towards learning the structure of the section at Henderson. At the time the examinations were made along the line of this road no opportunity was had to prove the accuracy of the record. Upon comparing it with well-known records of other shafts, and with the natural sections obtained in the hills, in other parts of the coal field, there would seem to be room for doubts concerning some of the details of the section as given to Dr. Owen; but beyond that nothing can be said concerning it at present. They may be perfectly accurate.

The following is the section of "Schlesinger's shaft" (worked by a miners' coöperative company), on the railroad, about one mile and a half, or two miles south of Henderson:

1.	Earth, etc.—"yellow surface earth"	18 feet.		
2.	Blue Shale? ("blue mud")	35 "		
3.	"Gravel" (?)	7 "		
4.	"Limestone; hard and shelly"	1 "	2 inches.	
5.	Coal		9 "	
6.	Limestone	1 "	8 "	
7.	Blue sandy Shale	9 to 10 "		
8.	Space ("conglomerated material")	5 to 6 "		
9.	Sandstone	39 "		
10.	Sandy Shale; colors brown and blue. Probably Black Slate at the bottom. (This was drilled through in part)	34 "	6 "	
11.	Coal	4 "	10 "	
12.	Under clay	2 "		

The record was obtained from the sinkers of the shaft, at the time the sinking was in progress. In the main it may be considered as about correct. The top of the shaft is about level with the railroad.

The first plain exposures of the beds are found at Sebree. At this place a peculiar disturbance crosses the path of the railroad and is exposed in the cut just beyond the Sulphur springs. About 300 feet north of the cut, near the springs, masses of Sub-carboniferous limestone are strewn somewhat

irregularly over the surface of a hill which rises to a height of about 30 feet above the level of the road. Masses of calcite are distributed through some parts of the limestone, which is also crossed by veins of that mineral. Some parts of the rock are also studded with concretions of black chert, while others are full of minute cavities containing bitumen. A few specimens of *Bryozoæ* were found. Although the rock is nearly destitute of organic remains, by which to determine its age, there is little doubt, when its general features are considered, that its position is below the coal measures. The type of the *Bryozoæ* would indicate as much.

In the cut just beyond (southwardly), however, beds belonging to the coal measures are exposed, inclining at high angles; and the inclination is *towards* the Sub-carboniferous limestone, instead of away from it. This is shown in figure I, plate I.

So far no explanation has been found for this peculiar condition of the beds. The structure of the region in the immediate vicinity of the fault is nearly entirely masked; indeed, so effectually is it concealed that, had the railroad, by a slight curve, passed round the point of the hill through which it cuts, one might have passed over the ground without suspecting such an arrangement of the beds. As shown in the figure, the beds rise southwardly.

The following is an approximated section of the strata, beginning at the north end of the cut:

1.	Sandy Shale, with occasional nodules of Iron-stone, about	60 feet.	
2.	Sandstone. This is much shattered. The texture of the rock seems to be quite variable, changing from fine to coarse-grained in its various parts	60 to 70 "	
3.	Coal dirt, apparently	3 "	
4.	Under clay	3 "	
5.	Coal dirt	4 inches to 1 "	
6.	Argillaceous Shale, some parts calcareous	10 "	
7.	Fine-grained drab limestone. This weathers a mottled ashy-white color splotched with brown, and is rough on the weathered surface. The organic remains found in it are: *Martinia plano-convexus*, an *Archæocidaris spine* (?), *Crinoid* columns, and *Chætetes milleporaceus*	2 "	6 inches.
8.	Shale		6 "
9.	Coal stain		4 "
10.	Dark blue and greenish Shale	9 "	

11. Shaly Sandstone	5	feet.
12. Compact Sandstone—base not seen	10	"
Total thickness, about	174	" 4 inches.

The precise position occupied by these beds in the section of the coal measures, as exposed along the road, is as yet conjectural. About half a mile beyond the cut, towards the south, comparatively horizontal beds are exposed, as shown on the profile section, and there seems to be little chance for these beds to have been brought up from below. First impressions would seem to point to their having occupied a position higher than the comparatively horizontal strata to the south. Until the details of the disturbance become plainer, however—and this end is only to be obtained by detailed examinations made along the course of the fault—any conjectures that may be held concerning the proper position of the beds are of little value.

There is little doubt that this disturbance is connected in some way with the "Rough Creek uplift," of Ohio county, either as a direct continuation of the disturbance or as an "offshoot" of it. The evidence is pretty clear that the "Rough Creek uplift" does extend at least into Webster county, although the matters of detail concerning it may change at various points along the line.

One of the usual phenomena connected with lines of faults is to be observed here; at the base of the hill, upon which the Sub-carboniferous limestone is exposed, several springs of sulphur water break forth.

These springs, in connection with one of chalybeate water, which issues from beneath a sandstone about half a mile further south, have caused Sebree to be known somewhat as a watering-place. A hotel has been erected near them for the comfort of summer visitors, numbers of whom come from Evansville, Henderson, and other places during the proper season.

Following are analyses of water from one of the sulphur springs, and from the chalybeate spring. It is proper to state that the collections were made at an unfavorable time—during

a period of heavy rains—and fresh water had mingled with that of the springs to a considerable extent.

FROM THE "SULPHUR SPRING." IN 1000. PARTS.

Iron and manganese	0.0007	Held in solution in the recent water by free carbonic acid.
Lime carbonate	.2178	
Magnesia carbonate	.0499	
Lime sulphate	.0617	
Magnesia sulphate	.0570	
Potash sulphate	.0042	
Soda sulphate	.1433	
Sodium chloride	.2760	
Silica	.0176	
Organic matters and loss	.0076	
Total saline matters	0.8358	Dried at 212° F.

As stated by Dr. Peter, in the chemical report, this is undoubtedly a good "saline sulphur" water.

FROM THE "CHALYBEATE SPRING." IN 1000. PARTS.

Iron carbonate	0.0297
Manganese carbonate	trace.
Lime carbonate	.0247
Magnesia carbonate	.0179
Lime sulphate	.0218
Potash sulphate	.0042
Soda sulphate	.0205
Sodium chloride	.0026
Silica	0010
Organic matters and loss	.0066
Total saline matters, dried at 212° F.	0.1290

This is very apparently a good chalybeate water.

About half a mile north 13° east from Sebree, on the north side of the disturbance mentioned above, a coal bed barely 2 feet thick crops out on Mr. W. J. Marshall's place, in the bank of McAvoy's creek. The bed dips at an angle of 2°(?), course about north 55° east. Quaternary clays rest upon it, and very little knowledge could be gained concerning it.

Beyond Sebree, towards the south, there is a space of nearly half a mile in which the relative positions of the beds are obscure. At the chalybeate spring, mentioned on a preceding page, a massive sandstone, underlaid by shales, comes to view, the base being about 15 feet above the railroad. This is a marked feature in the structure of the region for a considerable area about the spring.

At a mile beyond Sebree the sandstone and shale are exposed in the following order:

1. Massive Sandstone; hard and compact, and frequently "honeycombed" on the surface. The bed seems to be dipping somewhat, course about north 15° west . . . . . 25 feet.
2. Sandy Shale, the base not seen. . . . . 15 "
3. Space to the railroad, probably filled with Shale. . . . . 8 "

The total thickness of the sandstone seems to be at least 40 feet.

The shale underlying the sandstone seems to form the substructure of the ground through "McElroy's Gap," nearly if not quite to Deer creek. About half a mile beyond Deer creek 10 feet of sandy shale is exposed, the top of the bed level with the railroad, which may underlie the rocks of McElroy's Gap, as the beds seem to be rising towards the south.

Somewhat less than three quarters of a mile beyond Deer creek, a few yards south of the Dixon road, a limestone is exposed in the field of Mr. G. W. Croly. No perfect exposure of it was found; but the base seemed to be about 35 feet above the railroad at the crossing of the Dixon road (known as the "Dixon Crossing"), and 60 feet above the bed of Deer creek. The limestone has a dark bluish color upon a freshly-fractured surface, and weathers an undecided ferruginous brown. It seems to contain very few fossils. *Productus splendens*, *Spirifer cameratus*, and *Martinia plano-convexus* were found; the specimens were scarce. The place of this limestone has not been determined; it resembles, in some of its features, one or two definitely known limestones; but the exposure of it is so limited that its precise character and position cannot be decided upon at present.

In the Dixon road, about one mile westwardly from the Dixon Crossing, a coal stain makes its appearance, whose position is apparently about 50 feet above the limestone seen at Mr. Croly's. This, however, has not been verified.

From this point to Slaughtersville the region through which the road runs is mostly flat land, and the order of the beds is not well seen.

A short distance north of the 120th mile-post, about one and a half miles northwardly from Slaughtersville, a limited

exposure of sandstone and shale is found. The sandstone is exposed for 5 feet of thickness, and is overlaid by 3 or more feet of shale. It seems probable that these beds contribute most largely to the surface structure of the region near the railroad for the larger part of the distance to Slaughtersville.

About two miles northwestwardly from Slaughtersville a thin coal bed has been discovered, on land belonging to Mr. John Quarles. The bed measures somewhat less than 14 inches at its outcrop. It is overlaid by 18 inches or 2 feet of black bituminous slate, the upper part of which is soft and fragile at the outcrop. The position of this coal is dotted on the profile section at a point about one quarter of a mile northwardly from the 120th mile-post from Nashville, and is placed provisionally at 75 feet (its *apparent* height) above the railroad at that point, and 70 feet above the road-bed at Slaughtersville.

At Slaughtersville we enter the flat lands of the East Fork of Deer creek. Shale forms the sub-structure of the flat around Slaughtersville, as proved by a pit sunk near the railroad depot; but no good exposures of it are to be found. Just back of the station a hill rises to a height of 65 feet above the low land, and even higher towards the northwest; but no available outcrops are found on it.

From Slaughtersville southwardly the ground ascends, and sandstone is occasionally exposed in the hills. No distinct exposures are found, however, much nearer than the large railroad cut, about two and a half miles from Slaughtersville.

At this cut we find an instructive section, the beds of which seem to form the larger part of the surface structure as far south as Madisonville—a distance of eight and a half miles.

As shown on the profile, the section is composed of a massive sandstone and shale beds, arranged in the following order:

1. Massive variegated Sandstone. This is a loose-grained, rather soft sandstone, much cross-bedded, variegated with white, brown, drab, and pink colors . . . . . 40 feet.
2. Greenish Sandstone, alternating with beds of Shale . . . . . 15 "
3. Greenish sandy Shale. This, when comparatively dry, is an olive-green; when damp, it is dark or nearly black; base not seen . . . . . 15 "

As shown in figure 2, plate I, the massive sandstone No. 1 is fractured in such a manner, towards the north end of the cut, as to allow one part of the bed to sink below the level of the other parts, forming, in this manner, a small fault. There are, indeed, two lines of faulting in the cut, so that, although the underlying shale is apparently cut off by the sandstone a short distance north of the south end of the cut, it is exposed again near the middle, and disappears entirely at the north end, where the sandstone is again let down. In the cut just south of the large cut, which, for convenience, has been called the "Great" Cut, shale beds are exposed which underlie the sandstone of the "Great" Cut.

The following is the section exposed in the cut and a short distance south of it:

1. Argillaceous Shale, containing ochreous concretions; top not seen . .	5	feet.
2. Coal stain	⅛	"
3. Whitish underclay	1½	"
4. Greenish sandy Shale, in some places merging into thinly-bedded or shaly Sandstone; ochreous nodules are scattered through it	15	"
5. Coal dirt	½	"
6. Shale.	10 to 15	"

In the cuts southward, to Hanson, sandy, shaly beds are exposed. These seem to be chiefly the underlying beds near the surface, for some distance on either side of the road, between the Great Cut and Hanson. They are probably below the beds exposed at the Great Cut.

At Hanson a shaft was sunk, it is said, to a depth of 40 feet, by Messrs. Sebree & Co., in 1867 or 1868, reaching a level about 45 feet below the railroad. Coal is reported to have been found at the bottom, measuring 4 to 5 feet in thickness; the material passed through before it was reached is reported to have been shale and sandstone. I was unable to verify the report by personal observations; nor could sufficient data be gathered in the neighborhood to indicate, with certainty, what coal should be found at this point at such a depth. Coal is also reported to have been found within a mile of Hanson showing a thickness of 4 feet.

Hanson lies in an extensive flat, on the waters of Otter creek. From the station to the 110th mile-post (from Nash-

ville), a distance of three miles, no exposures of the strata are found, although there is a general upward sweep of the ground in that direction. The topography, however, is that of soft sandstones associated with beds of shale. Beyond the 110th mile-post the upper series of beds begin to show more plainly.

In the second cut south of the 110th mile-post—about half a mile beyond it—15 inches of coal dirt is exposed. This is probably (?) the equivalent of the first coal above the "South Carrollton" Limestone, as seen in the Green river bluff. Very little data could be obtained concerning it, however, so that its general extent and precise relations could not be definitely determined.

The following is the section at the cut:

1. Thickly-laminated sandy Shale	10	feet.
2. Coal dirt	1¼	"
3. Sandy Shale; base not seen, to level of railroad	2	"

There is little doubt that the bed is above the Madisonville Limestone (described on a succeeding page), and is not far below the base of the massive Variegated Sandstone which lies above the limestone.

In the large cut just north of the 109th mile-post a massive, soft, disintegrating sandstone, 20 to 25 feet thick, is exposed. It is much cross-laminated. This is probably the Variegated Sandstone, described at another place.

In the railroad, a short distance south of the 109th mile-post, lower beds come to view.

From this point to Madisonville the southwardly rise of the rocks is apparent. About one mile and a half to two miles northwardly from Madisonville, in the Slaughtersville road, the highest point in the region seems to be found, with an incoherent sandstone capping the summit.

The following is the section of the beds, so far as exposed, from the summit of the hill to the railroad crossing, about half a mile northwardly from Madisonville:

1. Soft, loose-grained, but massive Sandstone, variegated with pink, white, drab, and brownish colors. Upon long exposure the bed disintegrates and forms a bank of sand. This has been called the "Variegated Sandstone" . . . . . 30 feet.
2. Covered space. This is apparently mostly filled with greenish sandy Shale and thin bands of Sandstone . . . . . 30 "
3. Greenish Sandstone in thin layers, with shaly partings. To the railroad. . 20 "

All the cuts from this point to the first cut south of the Madisonville depot, a distance of three quarters of a mile, expose greenish-tinged sandstones and shales, which succeed, in descending order, the beds enumerated in the section given above. On the east side of the railroad, by the spring opposite the water-tank, a thick bed of limestone is exposed, which has been temporarily called the "Madisonville Limestone." The rock resembles that seen at South Carrollton, and it is probably identical with that bed. It will be remembered that the two towns, Madisonville and South Carrollton, are on the same line of elevation. The Variegated Sandstone, which occurs at 60 feet above the limestone at Madisonville, may be identical with the massive bed exposed in the Green river bluff, 50 feet above the "South Carrollton Limestone."

The following is the section of the beds exposed at the spring:

1. Disintegrating very micaceous, variably coarse and fine-grained Sandstone. Some parts are very ferruginous, but the general colors are greenish-grey and brown. Cross-lamination is very frequent in the mass. . . . 10 feet.
2. Space, probably filled with Shale, merging into sandstone at the top. . . 5 "
3. Space, apparently all Shale . . . . . 5 "
4. Massive Limestone. Is drab and dove colored usually; some parts are blue. The rock weathers a dirty ash color, shading into light ferruginous brown. *Martinia lineatus* (*or M. plano-convexus*) is abundant . . . 4 "
5. Nodular Limestone. . . . . 1 "
6. Shale and nodular Limestone, somewhat resembling marlite. This thickness is variable. . . . . ½ "
7. Blue Shale. . . . . ½ "
8. Limestone, covered in many places with mammillary incrustations of *Chætetes milleporaceus*. Varies from 6 inches to . . . . . 1 "

It is possible that the full thickness of the limestone is not seen here.

In the cut just south of the water-tank, opposite which the foregoing section was made, the limestone is exposed, and shows a greater thickness, or rather a different arrangement, of the beds.

The section is:

1. Soft Sandstone	8	feet.
2. Coal dirt. This disappears towards the south	½	"
3. Massive Limestone; abounds in *Productus splendens* and contains *Spirifer cameratus* and a *Cyathophylloid* coral	4½ to 8	"
4. Greenish-grey sandy Shale	5	"
5. Limestone, rather mottled and somewhat of a brecciated appearance. The upper part, for 6 inches, is nodular and is frequently charged with fossils, viz: *Martinia plano-convexus, Martinia lineatus? Macrocheilus inhabilis, Chonetes mesoloba,* and a *Rhynconella.* The general color of the Limestone seems to be grey mottled with red	3 to 4	"
6. Dark blue Clay, merging into Shale below; somewhat calcareous near the top; base not seen	3	"

The limestone bed No. 3 has quite a limited extent. It is most fully developed near the central part of the cut; towards the southern end it disappears.

Passing southwardly from Madisonville, we find the beds which underlie the "Madisonville Limestone" occasionally making their appearance, though the connection is not unbroken. Two miles and a half from Madisonville coals A and B make their appearance on Mr. Earle's land. Their position is about 80 feet below the Madisonville Limestone. Coal B has been mined to some extent. The following is the section at the bank:

1. Covered space; fragments of Sandstone seen on the slope of the hill	65	feet.
2. Coal "A," showing as a coal dirt	1½	"
3. Limestone; this varies in thickness. It is sometimes represented by worn fragments imbedded in clay	3 to 3½	"
4. Clay Shale, about	½	"
5. Bituminous Slate and Shale, divided thus:		
a. Slabby black Slate — 1½ feet.		
b. Friable slaty Shale — ½ "	2½	"
c. Slabby black Slate, 5 inches to — ½ "		
6. Coal "B." The base of the bed was not seen. The bed is divided by a clay parting, thus:		
a. Coal, the "upper bench" — 4 feet 7 inches.		
b. Clay — 2 "	6½	"
c. Coal; base not seen — 1 " 9 "		

This bank is a "drift" driven in the north end of a ridge which courses southwardly, towards Earlington.

The coal has been opened by Mr. Peyton and others, at points further to the west.

At Earlington a number of coal mines are in operation, namely: the "Hecla," the "Fleming" (formerly known as the "Diamond"), and the "St. Bernard" drifts.

The Hecla mines consist of a drift driven into coal B and a shaft sunk to coal D.

At the Fleming mine coal B alone is wrought, and is reached by drifting.

The St. Bernard drifts are in coals B and D, respectively.

The southwardly rise of the strata is very apparent at Earlington.

Were the bed worked at the Earle bank extended horizontally towards the railroad, it would occupy a position about level with the road-bed, as indicated on the profile. Then at the Fleming mine, about 1,700 feet towards the south, the coal is found showing a rise of ten feet in that direction, while the southwardly rise from the Fleming mine to the upper or "Number Eleven" drift (as it is generally known), is about 53 feet; the total rise is about 63 feet in about 4,600 feet of distance.

THE FLEMING MINE.

This is the most northwardly of the Earlington mines. Coal B is the bed wrought. Its usual thickness, including the clay parting, is 6 feet; the maximum thickness is said to be 8 feet.

The following is a section of the beds at the drift:

1. Coal A. Said to measure		5	feet.
2. Calcareous Shale, with nodules of Limestone distributed through it		2½	"
3. Bituminous Slate	3 inches to	2	"
4. Coal B, divided thus:			
a. Coal	4 feet.		
b. Clay	½ to 2 inches.	6	"
c. Coal, nearly	2 "		
5. Space to railroad, about		10	"

The upper 15 inches of the upper bench is said to be the best part of the coal.

Following are analyses of the upper and lower portions of the bed:

Composition.	1	2
Moisture	2.70	3.04
Volatile combustible matter	40.74	36.90
Fixed carbon	51.64	49.06
Ash	4.92	11.00
Total	100.00	100.00
Sulphur	1.502	5.955
Specific gravity	1.290	1.366

No. 1 is the analysis of the upper portion; No. 2 is of the lower "bench."

THE HECLA MINES.

These mines are located on the westward side of the railroad. Three coals, A, B, and D, have been opened by the company, but only two of them, B and D, are wrought; the larger part of the mining is done in coal D. Coal B is reached by drifting. Its thickness is said to average 6 feet 8 inches.

Following are analyses of the coal. No. 1 is an analysis of averaged samples taken from all parts of the bed—from both the upper and lower member; No. 2 is an analysis of averaged samples taken from the lower member:

Composition.	1	2
Moisture	3.28	3.82
Volatile combustible matter	39.32	36.38
Fixed carbon	49.54	51.10
Ash	7.86	8.70
Total	100.00	100.00
Sulphur	4.710	3.639
Specific gravity	1.323	1.326

Coal D is reached by a shaft of 60 feet in depth.

The following is the section, beginning at the base of coal B, of the materials passed through in the shaft, as reported by Thomas D. Roberts, the underground manager:

1. Coal A	4 feet	10 inches.
2. Fire-clay		11 "
3. Limestone	2 "	
4. Calcareous Shale. Dark colored and filled with specimens of *Martinia plano-convexus*		6 "
5. Bituminous Slate		6 "
6. Coal B	6 "	8 "
7. Sandstone; the upper 18 feet may be shaly, the lower part, however, is compact	38 "	
8. Mostly argillaceous Shale	20 "	
9. Bituminous Slate	2 "	
10. Coal D	4 "	8 "

This mine was opened in May, 1873. In July, 1875, about thirty-five rooms had been turned off.

The coal is raised from the pit by steam power. The mining arrangements seemed to be excellent of their kind. The mine is under the management of Mr. J. F. Ford.

Following is an analysis of averaged samples of coal D:

Moisture	2.32
Volatile combustible matter	37.68
Fixed carbon	51.00
Ash	9.00
Total	100.00
Sulphur	3.606
Specific gravity	1.331

THE ST. BERNARD MINES.

The rise of the rocks to the southward is such that both coals, B and D, are worked at these mines, and are both reached by drifting; the two drifts are about one quarter of a mile apart.

Coal B is worked at the "Upper" drift, or the one furthest north from the railroad depot at Earlington; the coal D drift is a short distance north of the depot, and enters the hill at a level about ten feet above the railroad.

At the coal B drift the thickness of the bed will average about six feet; it is reduced to five and a half feet in places. As is characteristic of the seam, the bed is separated by a clay parting into two divisions; the upper member measures 4 feet, and the lower member 2 feet in thickness.

The upper 15 inches of the bed is admirable coal, and is known as the "gas coal;" this seems to be a general feature

of the bed, not only at the several mines around Earlington, but at various other places where this seam is wrought; its merits will receive attention in another report. From the bottom of the "gas coal" down, towards the bottom of the upper member, the coal seems to deteriorate in quality, the lower parts being more sulphurous than the upper portions.

The lower member (2 feet) is generally quite poor, compared with the better parts of the bed. Bituminous slate occasionally covers the coal; but usually limestone forms its immediate covering.

The following is an analysis of averaged samples collected from the upper member of coal B:*

Moisture	3.20
Volatile combustible matter	38.30
Fixed carbon	48.50
Ash	10.00
Total	100.00
Sulphur	3.345
Specific gravity	1.326

The coal D drift was not in operation the day these mines were visited.

The seam varies from 3 to 4½ feet in thickness, and the quality of the bed seems to improve where the thickness diminishes. The coal dips about 2°, course north 75° east.

The collections made for analysis were obtained along the entries. The following is the analysis of averaged samples:

Moisture	4.30
Volatile combustible matter	37.64
Fixed carbon	50.56
Ash	7.50
Total	100.00
Sulphur	2.892
Specific gravity	1.337

* For the method of sampling coals for analysis, employed in the western coal field, see page 47, part VI, volume I, Geological Reports of Kentucky, second series, N. S. Shaler, Director.

It will be seen that there is comparatively little difference in the quality of the coal worked at the different openings. The market rating of the product of the respective mines probably depends, in a large degree, on the amount of care taken in handling the coal.

The southwardly rise of the beds is continued beyond Earlington, and coal D is brought up still higher at Mr. Arnold's bank, about one mile and a half, or less, beyond Earlington. The bank was not working when visited. At the mouth of the drift the coal measured 4 feet 3 inches. This coal is in a low ridge which comes in between Earlington and Mortonsville.

Coal D (?) has also been opened a short distance beyond Mortonsville, but could not be measured, the excavation having become filled.

From this point to the Diamond mine, about three quarters of a mile beyond Mortonsville, the beds underlying coal D form the structure of the lower land, while sandstones and shale, and other beds associated with coal D, form the upper parts of the hills; the strata rise steadily towards the south.

At the "Diamond" mine coal D is found at a level 30 feet above the railroad, which is 73 feet higher at this point than at Earlington—a southwardly rise of 81 feet in 4½ miles thus being shown.

The following is the section, so far as exposed, at the Diamond mine:

1. Hard Sandstone	10	feet.		
2. Covered space	15	"		
3. Coal (A or B)	1	"		
4. Covered space	75	"		
5. Bituminous Slate	4	"		
6. Pyritous Clay Shale, containing the characteristic fossils of coal D,			6	inches.
7. Coal D	4	"	10	"
8. Covered space to the railroad	30	"		

Beyond the Diamond mine, towards Nortonville, a gap of about a mile occurs in the section, the direct connection between the beds being obscure. At one time this gap was thought to include a line of fracture of the beds. Subsequent observations, however, more perfect in their way than those first taken (though still quite imperfect in many re-

spects), have failed to prove the existence of such a line. But, at the same time, the non-existence of such a fracture has not been proved, and until a better map than we now have of this region may be constructed, and data more detailed in their character be collected, the conditions below the surface will remain problematical.*

At a saw-mill near the railroad, about one mile beyond the Diamond mines, a sandstone is exposed in the hills, and continues to crop out at various points to within somewhat less than half a mile of Nortonville, the Nortonville flat then setting in. In some places the sandstone seems to be at least 30 feet thick.

On the east side of the railroad, somewhat more than a quarter of a mile north of Nortonville, Mr. Wm. Mills has opened a bed of coal said to be 6 feet 8 inches thick. This place was visited for the first time in October, 1874. Since then it has been found necessary to revise some of the conclusions arrived at concerning not only this coal bed, but certain other points relating to the structure of the region about Nortonville.

The reasons for this are simple. Some of the data which entered largely into the foundation of the conclusions were necessarily received from others, since they related to beds which had been laid bare by excavations, but were, at the time, concealed. No opportunity has since occurred to see the beds perfectly, but sufficient evidence has been found to prove the existence of inaccuracies in some of the descriptions furnished me, and, consequently, of errors in the conclusions based upon them.†

When Mr. Mills' bank was visited for the first time the coal was concealed, the roof of the mine having fallen in; but the description given of the bed agreed so closely with that of coal B that, the region to the north not having been studied

* A fracture and fault is plainly visible at Rocky Gap, coursing in an eastwardly and westwardly direction; but until that point is properly located in regard to the surrounding region, it is impossible to determine just where the line crosses this railroad.

† It may be proper to state that such inaccuracies as occurred in the descriptions were doubtlessly unintentional on the part of those who furnished them.

closely, the bed was considered identical with that number, and is so recorded in the report on the geology of the region adjacent to the Louisville, Paducah and Southwestern Railway.* Since that time the outcropping of the coal has been found, and more perfect data have been obtained from Mr. Mills. The results of the subsequent examinations, although not sufficiently definite to determine the precise relative position of the coal, plainly show the bed to be another one than coal B, and seem to indicate its position to be far below the level of that bed.†

When first encountered the bed was divided, by a parting of eighteen inches to two feet of clay, into two members, as may be seen at the outcrop. It is said, however, that the parting either disappeared entirely, when the coal had been followed well under the hill, or became so thin as not to be noticeable.

The coal is covered by argillaceous shale, and seems to underlie the massive sandstone seen in the hills to the north.

Just north of Mr. Mills' coal bank the Nortonville flat sets in and extends southwardly beyond the Elizabethtown and Paducah Railroad.

A short distance beyond the Nortonville depot the railroad mounts a ridge, cutting through beds of sandstone as it ascends.

At the base of the ridge, just west of the railroad, Mr. Mills sunk a well or pit to a depth of about nineteen feet, or somewhat less, reaching coal at twelve feet below the surface. Fragments of the coal were seen in the débris at the mouth of the pit. Efforts were made to see the coal bed, but failed on account of the water in the pit. The coal is said to

* Part VI, volume I, second series Kentucky Geological Survey, N. S. Shaler, Director.

† As may be presumed, these modifications will affect the conclusions drawn concerning the structure of the section between Nortonville and Rocky Gap. That section has been examined once again, and under more satisfactory conditions than existed during the first reconnoissance. A line of fault which has hitherto been concealed was clearly established at Rocky Gap; glazed surfaces of sandstone, slickensides, etc., phenomena common to lines of fracture, besides a distinct downthrow of the beds on one side, were observed. These and other data recently gathered will materially simplify the work of interpreting the structure of the region. The results of these investigations, and the section as modified by them, will be given hereafter, when the more detailed work of the region is undertaken.

measure about seven feet in thickness, having a clay parting near the middle of the bed. The section given for the well is:

a.	Sandstone, about	5 feet.
b.	Argillaceous Shale	7 "
c.	Coal	7 "

This bed is probably equivalent to that opened by Mr. Mills north of the station. The top of the coal is about level with, or a little below, the bed of the railroad by the depot.

In the hill the sandstone passed through in the upper part of the pit is well developed.

The following is the section of the beds exposed in the ridge:

1.	Covered space, slope from top of hill	35 feet.
2.	Sandstone	30 "
3.	Covered space	10 "
4.	Dark earthy-blue, somewhat pyritiferous Limestone; generally hard and compact, rather tough, fractures irregularly. Fossils scarce and very poorly preserved; *Productus muricatus?* a small *Athyris?* and a few small *Crinoid* columns were found. The rock forms a distinct terrace along the side of the ridge . . . . . 2 feet 9 inches to	4 "
5.	Covered space	15 "
6.	Drab and grey massive Sandstone. This is quite variable in texture, and somewhat in color also. In some places it is quite compact and forms bold escarpments; in others it is brownish to buff colored, coarse-grained, soft and disintegrating, and much cross-laminated. It is usually very micaceous	40 "
7.	Argillaceous Shale	7 "
8.	Coal, reported to be	7 "

The beds from No. 1 down to No. 6 are exposed a short distance west of the railroad. The sandstone No. 6 is partially exposed in the cut immediately south of the depot, and seems to extend for about one mile towards the south, sandstone resembling it being exposed in the cuts as far south as the 94th mile-post (from Nashville). The beds in the cuts nearest the mile-post, however, may partly underlie the massive sandstone, as the strata appear to be rising towards the south. Beyond the 94th mile-post we begin to descend to the waters of Drake's creek, and a gap of nearly two miles occurs in the section—extending from the 94th mile-post to the railroad tank a short distance north of the 92d mile-post. In the fourth cut south of Nortonville shale and sandstone are exposed, which probably underlie the coal found in Mr. Mills' well.

Descending from this cut, we soon reach the "Drake's Creek Flats," which seem to be chiefly underlaid by shales. Sandy shale comes to view in a small branch a short distance beyond mile-post "ninety-three."

It is possible that the Rocky Gap fault crosses somewhere in the space between mile-posts 94 and 92; but the determination of this will have to await the completion of a better map than we now have of this region, and a careful tracing of the line of the fault. The structure of the section is obscure, until we reach the tank north of the 92d mile-post. At this point the railroad cuts a spur of a ridge coming in from the northwest, and exposes a fine section of the beds.

The following is a statement of their order:

1.	Covered space; fragments of Sandstone seen on the surface	25 feet.
2.	Limestone; texture earthy, color blue; shelly towards the top. Fossils are abundant. *Productus splendens* (especially abundant), *Prod. costatus*, *Spirifer cameratus*, *Prod. muricatus*, *Prod. Prattenianus*, *Martinia lineatus?* *Lophophyllum proliferum*, *Crinoid* columns, and a *Fenestella* were found. The bed is divided into two to three layers, and becomes more compact towards the bottom than at the top; the fossils are mostly found towards the top. The rock has the appearance of a "Hydraulic Limestone"	8? to 4 "
3.	Blue and drab Shale, somewhat ochreous; sandy towards the top	25 "
4.	Sandy argillaceous Shale	3 "
5.	Dark blue Shale, with streaks of coal	2 "
6.	Coal, base not seen	2 "

The thickness of the coal is reported at two and five feet, including a clay parting. Colonel Gano Henry, formerly of Hopkinsville, states that he dug into the bed, and found—

a.	Coal	3 feet.
b.	Clay	1 "
c.	Coal	2 "

It is probable, however, that his measurements were estimates, which are not always free from error. This bed is known as coal J in the reports of the present Survey.

About one thousand feet south of mile-post 92, a shaft, reported to be seventy-five feet in depth, was sunk, it is said, for the purpose of mining the coal exposed at the tank. The mouth of the shaft is *below* the level of that bed. Had the shaft been started at about fifteen feet higher up, the venture would have proved more successful. This mistake, however, was productive of considerable good, as those having the work in hand were induced to make a boring. The result was, so

I am informed, to penetrate coal L at a level about one hundred and thirty feet below coal J. The record of the boring assigns four to four and a half feet as the thickness of the coal. It would be unsafe, however, to vouch for the accuracy of the record at this point, as the thickness of the bed does not pass much beyond three feet at other points in the region where the coal is exposed. It is quite possible for some of the dark overlying material to have been mistaken for coal. Borings are valuable aids to the explorer; but when the thickness of a coal bed comes into question, they are far from trustworthy; neither is the reported existence of a coal bed always to be trusted—the degree of confidence to be placed in the record depending very much upon the person selected to determine the character of the materials as they are brought to the surface.

Combining the section made at the tank with the records obtained from Mr. Thomas of the materials passed through in the shaft and the boring, we obtain the following statement of the order of the beds near the tank:

1. Limestone	4	feet.		
2. Sandstone and Shale	32	"		
3. Coal J, reported to be	3	"		
4. Under clay	3	"		
5. Sandstone	15	"		
6. Shale and Coal	1	"		
7. Shale	12	"		
8. Coal			2	inches.
9. Fire-clay	3	"		
10. "Rash" Coal			½	"
11. Sandstone	8	"		
12. Coal	1	"	8	"
13. Space, probably Shale	13	"		
14. Bluish Shale and Sandstone	30	"		
15. Hard Shale and "gritty" beds of Sandstone	30	"		
16. Shale, "with iron ore"	2	"		
17. Shale	5	"		
18. Coal (L?)	4	"		

At the tank coal J rises rapidly north 20° east for a short distance; it seems to be a local disturbance of the bed, and not connected with any extensive movement.

The coal may be traced, either by its outcroppings or associated beds of shale and limestone, from the water tank to Petersburgh Station and beyond.

At Petersburgh a miners' coöperative company have sunk a pit to coal J, which was reached at a depth of about twelve feet below the level of the railroad. It averages four feet in thickness, including a clay parting one inch thick.

The section in the shaft is:

1. Compact bluish Shale			32 feet.
2. Coal, divided thus:			
a. Coal	3 feet 6 inches.		
b. Clay	1 "		4 "
c. Coal	5 "		
3. Under clay			3 "
4. Massive Sandstone; base not seen			4 "

An analysis of fairly averaged samples of the coal shows its composition to be:

Moisture	3.70
Volatile combustible matter	32.56
Fixed carbon	50.04
Ash	13.70
Total	100.00
Sulphur	3.716
Specific gravity	1.398

The analysis of this coal did not prove as favorable as was expected when the samples were collected. The coal is remarkable for the amount of fibrous coal interlaminated with the denser kind, and it is probable that its high per centage of sulphur is in a large degree due to this. It seems to be proven that the larger the proportion of fibrous coal there is in a coal, the larger will be the per centage of sulphur; a fact (if it proves to be a fact) which is well worth remembering when judging of its quality by the appearance of a coal.

The lower five inches of the Petersburgh coal is highly esteemed for smithing, and appears to be much freer from sulphur than the other portions of the bed.

Near the shaft of the miners' coöperative company, the limestone first above the coal is exposed in the road, and in Mr. Williams' field, near the house. In the road it is overlaid by shale (mostly) for forty feet.

Passing southwardly from Petersburgh, the rise of the beds is sufficient to bring coal J up to a level with the railroad at Edmunds, Green, and Norton's old banks, about one quarter of a mile, or somewhat more, southwardly from the town.

From this point southwardly the rise of the beds seems to bring the lower series regularly up to daylight, bringing up coal L at a point about one mile and a half beyond Petersburgh, where it was mined at one time; the banks are known as the Davis (?) banks. The bed worked at this place seems, undoubtedly, to be identical with that worked at the Coaltown banks, which are distant about half a mile from the railroad at this point. Several sections were made in the neighborhood of the Coaltown mines; but, as the region about them is soon to be studied closely, questions concerning the details of its structure are deferred.

Following are two analyses, made by Dr. Robert Peter and Mr. J. H. Talbutt, of average samples of the Coaltown coal collected in the summer of 1875. Analysis No. 1 is of a sample taken from a heap of the coal that had been exposed to the weather for some time. Analysis No. 2 was made of averaged samples collected in one of the drifts. It should be stated that there was considerable water in the mine when the collection was made, and that some of the moisture indicated by the analysis (No. 2) may be due to that circumstance.

By comparing the analyses, it will be noticed that, contrary to the usual conditions, the coal in the stock-piles contained less moisture than did the samples taken from the mine; hence, it is not improbable that neither analysis indicates the true proportion of the moisture, which is probably not greater than 3.5 per cent.

	1	2
Moisture	4.60	5.10
Volatile combustible matter	31.94	32.50
Fixed carbon	54.36	55.70
Ash	9.10	6.70
Total	100.00	100.00
Sulphur	2.469	1.277
Specific gravity	1.307	1.332

These analyses, when compared with those made by the chemists of the Kentucky Survey of coals of other States lying within the Illinois coal field, show very favorably for our coal.*

In the fifth railroad cut from Petersburgh, distant about two miles from the town, a short distance beyond the old Davis banks, the beds are dipping rapidly towards the north—nearly at the rate of ten feet in the hundred.

Passing southwardly from the old Davis banks, the series of beds lying near or at the base of the coal measures come to view, and within a short distance the border of the coal field is passed, though what appear to be outliers of the coal measures are found farther towards the south.

For the reason stated on a preceding page, it is deemed best not to enter into the closer details of the region bordering the limits of the coal field at present; but it may be well to notice some of the beds exposed in the cuts towards Hopkinsville.

In the cut about three hundred and fifty or four hundred feet south of the one mentioned above, the rocks are seen to be much disturbed. At the north end forty feet of sandstone is exposed, dipping northwardly, which is cut out by a fault that crosses the beds about the middle of the cut—the beds lifted by the fault resting nearly vertically against the others. On the south side of the lifted beds sandstone is found, thrown

*The question concerning the comparison of the quality of our coals with those of other States, lying within the same field, will be considered in a report to be given hereafter.

but little out of its horizontal position. A rough diagram of the condition of these beds is given in figure 1, plate V.

In the cut about 2,000 feet south of the foregoing one, the distinct base of the coal measures is seen, Chester limestone showing in the south end. About 1,200 feet farther south, the strata are considerably disturbed. Their order is, beginning at the north end of the cut—

1. Sandstone, dipping northwardly	20	feet.	
2. Shaly Sandstone, nearly vertical	12	"	
3. Coal		3	inches.
4. Shale	10	"	
5. Coal		1½	"
6. Shale, nearly vertical	30 to 35	"	
7. Sandstone	5	"	
8. Shale, vertical	80	"	
9. Shale, dipping northwardly	5	"	
10. Sandstone, dipping northwardly	5	"	
11. Shale, dipping northwardly	65 to 70	"	
12. Sandstone and Shale	10	"	
13. Shale	10	"	
14. Hard sandstone, dipping northwardly at an angle of 50° to 55°	25	"	
15. Olive green marly Shale (Chester ?)	15	"	
16. Chester Limestone		6	"
17. Marlite and Shale	3	"	
18. Dark Shale	1	"	
19. Sandy Shale, passing into Sandstone	20	"	
20. Variegated Sandstone, containing pebbles	50	"	
Total thickness	380	"	

This cut is about four miles and three quarters southwardly from Petersburgh Station, about one mile northwardly from Crofton, and one mile and a half southwardly from the Davis(?) coal banks.

From this cut to a point about half a mile southwardly from Crofton, the beds are imperfectly seen; sandstone seems to be the prevailing rock. At half a mile beyond Crofton, twenty-five feet of sandstone is exposed, which is apparently but little inclined; the exposure was too limited to determine the fact.

About one mile farther towards the south, the beds are again exposed, dipping towards the north. The following is their order, beginning at the north:

1. Dark blue sandy Shale, dipping at an angle of 35°, north 7° east,	15	feet.
2. Thin-bedded ferruginous Sandstone; dips 33°, course north 7° west	5	"
3. Dark drab Shale, dipping as No. 2	4	"
4. Coal	0 to	1 inch.
5. Under clay, containing an occasional *Stigmaria ficoides*	5	"

6.	Shale and soft shaly Sandstone	10 feet.	
7.	Coal, dipping 17°, course north 7° west		½ inch.
8.	Drab Shale, dips 17°	15 "	
9.	Thin-bedded Sandstone, dips 37°	10 "	
10.	Sandy material, probably crushed Sandstone with clay	4 "	
11.	Limestone—Chester Group—dips 57°		6 inches.
12.	Shale and thin plates of Limestone	5 "	
13.	Sandy Shale, with Limestone nodules; dips 7°	12 "	
14.	Irregularly-bedded Limestone, filled with *Bryozoans;* base not seen	7 "	

At the junction of No. 13 with No. 12 the beds are crushed down, as shown in figure 2, plate V.

This series seems to correspond in part to the beds exposed in the cut north of Crofton. The upper beds, including the coals, are the last exposures seen of the coal measures, near the railroad, southwardly. From this point on to Hopkinsville the Sub-carboniferous beds have entire sway.

Southwardly to Kelley's Station and beyond, a massive sandstone, underlying the beds exposed in the cut, forms the sub-structure of the ground. About half a mile beyond Kelley's, sandstone and shale, probably belonging near the base of the massive sandstone, come to view; and at half a mile still farther to the south limestone makes its appearance.

Passing a short distance beyond this limestone outcrop, and descending toward Hopkinsville, shaly sandstone makes its appearance, which probably underlies the limestone to the north, and overlies the St. Louis Limestone exposed at Hopkinsville. These lower beds of sandstone and shale are exposed occasionally as far south as the East Fork of Little river, on the banks of which, and beyond, the massive limestone of the St. Louis Group is exposed; the sandstone may be found on some of the hills.

The massive limestone is largely developed at and about Hopkinsville. Beds of admirable oölitic stone are exposed there, and are quarried for domestic purposes. These oölitic beds of the St. Louis Group seem to be the ones most valuable, for all purposes, that are to be found in the series.

The stone at Hopkinsville is easily dressed, firmly cemented, capable of being fashioned after any design, and, apparently, is durable; it also presents a good appearance when

set in a building. Polished specimens of this stone have been seen, and their appearance would seem to indicate that it would serve fairly well as a "marble" for certain indoor purposes. What merit the polished stone may have for outdoor use, however, is, to say the least, conjectural. Of the many limestones that receive a good polish, few are capable of sustaining it when exposed to atmospheric changes.* They become more or less pitted as the softer portions are eaten away. The well known Bowling Green oölite occurs in the same group as does the one in question. Quarries have also been opened in beds of the same description near Glasgow Junction and Princeton. Large shipments of the dressed stone are made from those points. There seems to be no good reason why such an industry may not gain a foothold at Hopkinsville.

One of the interesting points in connection with the beds at Hopkinsville is the bored well of Mr. John B. Trice. The well is one hundred and thirty-four feet deep, with a diameter of five and a half inches. The purpose in view when the boring was commenced was to obtain a trustworthy supply of fresh water. In this, however, the well has so far proved a failure; but it is not altogether a failure when other results are considered. On the contrary, at the depth of one hundred and thirty-four feet, a stream of water was encountered, which analysis proves to be not only valuable as a sulphur water (so far as the value of such waters can be estimated), but somewhat remarkable in its composition.

The following is an analysis made in the laboratory of the Survey of some of the water furnished by Mr. Trice:

* This stone has not been tested as to its liability to scale; but, judging from the condition of structures already built of it, it does not seem probable that the amount of disintegration will be great.

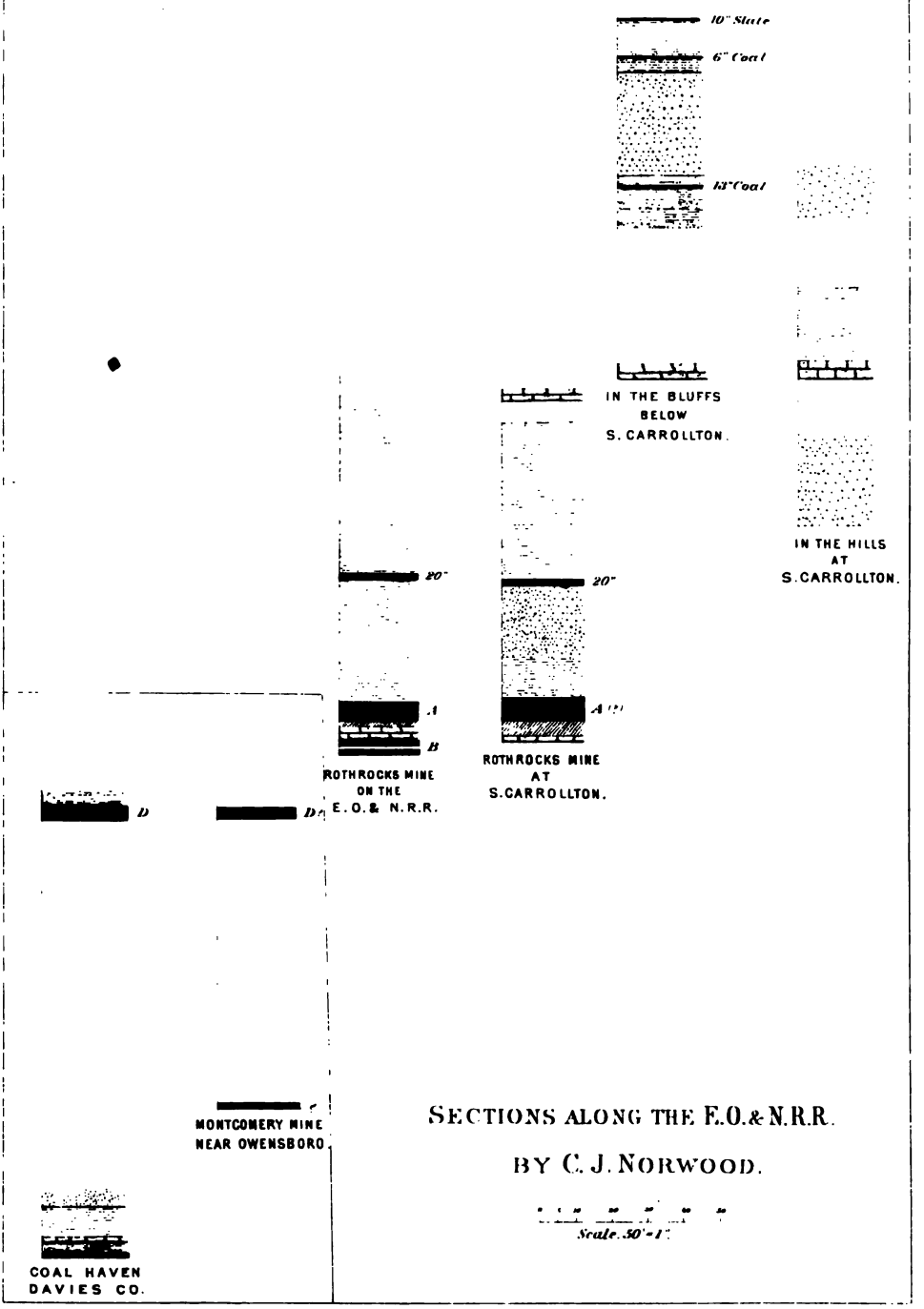
CONTENTS OF 1000. PARTS OF THE WATER.

Lime carbonate	0.1233	Held in solution by carbonic acid.
Magnesia carbonate	.0253	
Iron and manganese carbonate	.0013	
Silica	.0012	
In sediment formed on boiling	0.1601	
Sodium chloride	3.3647	
*Sodium sulphide	.....	
†Soda carbonate	.2366	
Soda sulphate	.5347	
Potassium chloride	trace.	
Lime sulphate	.1156	
Magnesia sulphate	.4329	
Magnesium iodide	.0018	
Lithia and Bromine	traces.	
Total saline contents	4.8464	

*Not estimated because partly decomposed.
†Representing the sulphide in the recent water.

This water was found in a greenish calcareous shale after one hundred and eighteen feet of limestone had been penetrated.

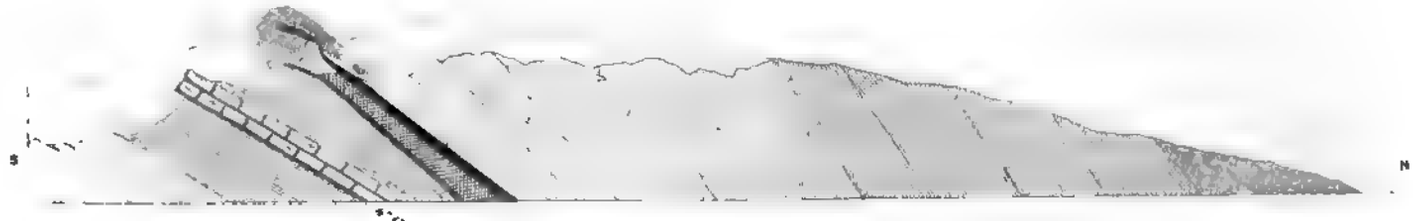
Plate I.



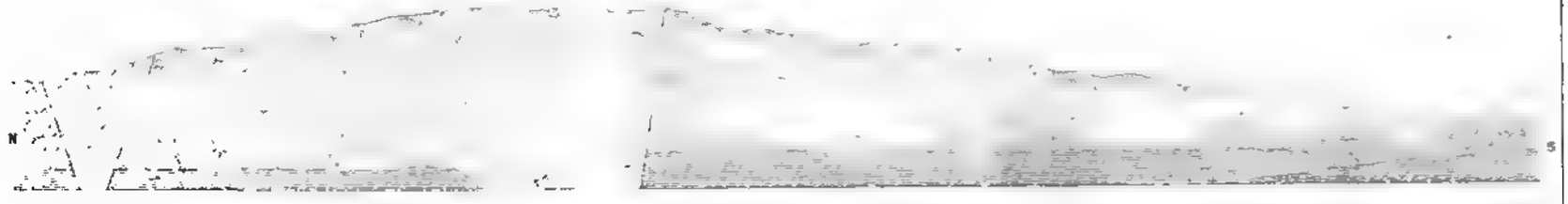
SECTIONS ALONG THE E.O.& N.R.R.

BY C. J. NORWOOD.

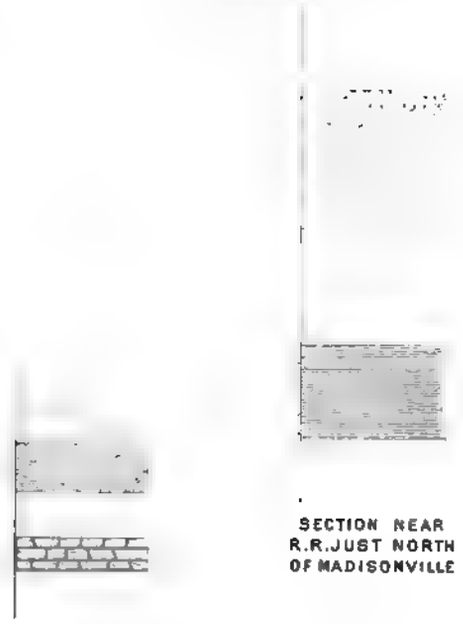
Scale. 50'=1"



SECTION ON R.R. CUT AT SEBREE WEBSTER COUNTY.



SECTION OF GREAT CUT NORTH OF MADISONVILLE HOPKINS COUNTY



SECTION AT THE MADISONVILLE SPRING

SECTION NEAR R.R. JUST NORTH OF MADISONVILLE

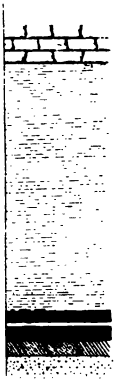
SECT. OF THE "HECLA" SHAFT.

HOPKINS COUNTY SECTIONS

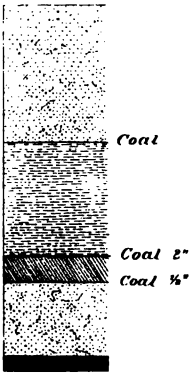
BY C. J. NORWOOD

Scale, 40ft.=1in

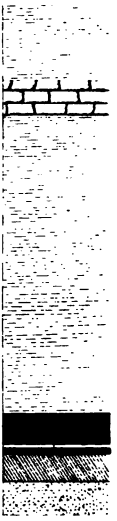
Plate. IV.



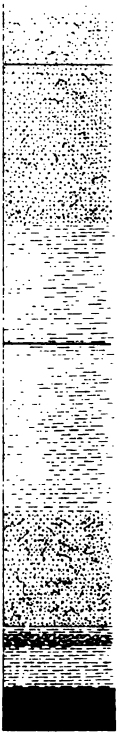
SECTION AT THE TANK NEAR MILE POST 92.



THE AIR SHAFT NEAR MILE POST 92.



THE PETERSBURGH SHAFT.



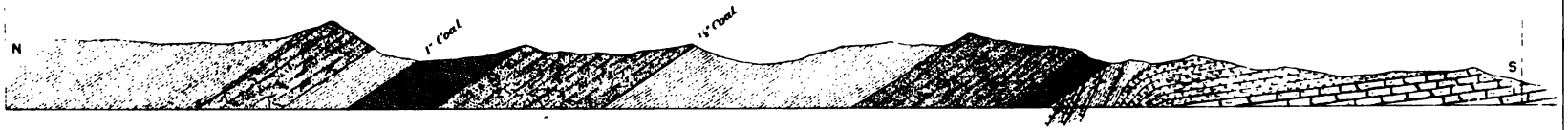
BORING NEAR MILE POST 92.

SECTIONS IN CHRISTIAN COUNTY

BY C. J. NORWOOD.

1877.

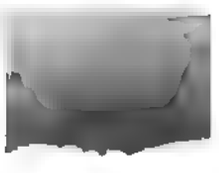
Scale, 20ft. to in.



CUT AT 82 MILEPOST STL & S.E.RWY CHRISTIAN COUNTY.

SIXTH CUT SOUTH OF PETERSBURG CHRISTIAN COUNTY

Plate V.



GEOLOGICAL SURVEY OF KENTUCKY.

N. S. SHALER, DIRECTOR.

A REPORT OF A RECONNOISSANCE

OF A PART OF THE

BRECKINRIDGE CANNEL COAL DISTRICT,

BY CHARLES J. NORWOOD.

PART VIII. VOL. IV. SECOND SERIES.

STEREOTYPED FOR THE SURVEY BY MAJOR, JOHNSTON & BARRETT, YEOMAN PRESS, FRANKFORT, KY.

339 & 340

INTRODUCTORY LETTER.

Professor N. S. SHALER, *Director Kentucky Geological Survey:*

DEAR SIR: In accordance with your instructions, I herewith present a report of a reconnoissance, made in 1875, on that part of the "Breckinridge Cannel Coal" district (lying partly in Breckinridge county and partly in Hancock county) which is known as the property of the "Cloverport Coal and Oil Company."

This report is largely a rearrangement of one made, by your direction, to Col. J. C. Johnston, of Louisville, Kentucky. As that report was partly written in the field, however, and within a limited time, some of the facts were not so carefully weighed as otherwise would have been done. A more careful study of my notes has shown the necessity of modifying some parts of that report, and some new matter has been added, so that, although largely a rearrangement of the one furnished Col. Johnston for his immediate information, this report may be regarded as more accurate and complete. The changes made, however, are comparatively few, and, under the circumstances, do not materially alter the value of the former estimates. Some new computations (based on a more recent determination of the specific gravity of the coal) have been made for the estimated amount in tons of the coal underlying the lands. This, to a certain degree, affects the estimate for the possible total income which may be derived from the property; but the effect would be apparent only in the future.

The work of computing the probable income which may be derived from mineral lands is always subject to revision, and, as in the present instance, serves rather for illustration than as a strict mathematical fact.

The yearly income is necessarily dependent on the price that the coal will fetch in the various markets. These prices fluctuate, and, as a consequence, an estimate made now for the probable income, using the present market value of the coal as a basis for computation, would be subject to revision at any time.

This, however, does not alter the value of the estimates for the use of those having experience in such matters.

The estimate for the cost of mining, etc., is subject to little change on account of fluctuations, and remains as given when the report was originally prepared.

Respectfully,

C. J. NORWOOD.

REPORT OF A RECONNOISSANCE OF A PART OF THE BRECKINRIDGE CANNEL COAL DISTRICT.

I.

DESCRIPTION OF THE PROPERTY, ETC.

According to the data furnished me, it appears that the various boundaries of the property of the Cloverport Coal and Oil Company inclose about 7,224 acres, lying southwardly from Cloverport, as represented in the following statement:*

In fee-simple	4,744	acres.
Mineral rights in perpetuity	1,970	"
Cloverport town and river property, on which stand the old factories and accessory buildings, the Superintendent's cottage, and "Cairn's Castle,"	60	"
The "Crawford" farm	436	"
A lot on the railroad	2	"
Railroad rights of way	12	"
Total	7,224	"

"The 'Crawford' farm is detached, lying about one mile and a half east of the principal body of the estate, which includes about 6,500 acres."

The especial value of the section examined lies in the deposit of cannel coal which is found on it. Several "entries" were driven by the "Breckinridge Cannel Coal Company," a number of years ago, for working the coal.† If the report is correct, these mines were at one time operated by their former owners solely for the manufacture of illuminating oil from the coal.

*Cloverport is on the Ohio river, 260 miles below Cincinnati. It is 110 miles below Louisville, 190 miles above Cairo (which is at the junction of the Mississippi and Ohio rivers), and 1,182 miles above New Orleans.

†The amount of coal removed by that company was, so far as can be learned, comparatively little. A report has been circulated somewhat to the effect that the deposit has been practically exhausted; but I have been unable to verify it in any way. There is in Col. J. C. Johnston's possession a map, said to be authentic, exhibiting the area of coal removed up to the time that the mining was suspended. Their condition was such that the old entries could not be surveyed when I visited them.

From a report of the directors, issued in pamphlet form, it is learned that the erection of the oil works was commenced by the Breckinridge Coal and Oil Company in the autumn of 1855, and that in April, of the following year, twelve retorts were in operation, producing from 600 to 700 gallons of crude oil daily. In June, 1856, that company and the "Breckinridge Cannel Coal Company" consolidated; following which, an extension of the works was undertaken, and, in the succeeding year, eighteen additional retorts were put in place.

All of the apparatus about the works was the best of its kind; and, had not the discovery of natural oils been made, there is little reason to doubt that a prosperous business would have followed.

Disastrous fires, the discovery of petroleum, and the commencement of the war between the States, all happening near together, however, caused the abandonment of the works till now, when, if the matter is correctly understood, it is desired to establish a colliery at the old mines, and mine the coal for general exportation.

Some knowledge of the extent of the cannel coal bed, incidentally taking into consideration the general worth of the property, and the estimated cost of placing the mines in working order once more, was accordingly desired.

Having a pressure of work in another direction, the time that could be given to this matter was limited, and was not sufficient for me to enter into such detailed explorations as would be desired for the preparation of a complete statement. So far as they were extended, however, the observations were such as would impress the observer with a high sense of the worth of the lands.

The surface of the region is naturally varied, according to the character of the underlying beds. Towards the Ohio river a sandstone is usually the first bed below the surface, and, as a consequence, there is a considerable proportion of comparatively flat or undulating surface in that direction; the same conditions are also found along some of the streams in the interior. The larger part of the property, however, is

hilly, the hills frequently rising rather sharply from the low-lands.

The tops of the hills are frequently "rolling," and furnish a few admirable localities for farms. A large proportion of the land, however—especially where, in the immediate vicinity of streams, the shale beds of the Sub-carboniferous Group are the first ones below the surface—is too broken to be desirable for farming purposes.

The most prominent feature in the geography of the region is a long, irregularly trending ridge, which passes southwardly through the property. It is said to vary from one quarter of a mile to two miles in width.

This ridge forms the water-shed for the region near it, and has a distinct value, not only topographically but geologically, as within its structure the bed of cannel coal is contained. Accordingly, to know the true form of the ridge becomes very necessary in order to determine with accuracy the extent of any of the beds contained within it. Until this shall be done, all work in that direction is, of necessity, estimative.

II.

AGRICULTURE.

The agricultural aspects of the property are fair, certain portions of the land being fairly well adapted for the growth of small grain, while some parts serve admirably for the production of tobacco. It may be said that, as a whole, this region will compare favorably with the general class of lands, with like geological conditions, in the southwestern portion of the State, for the growth of corn and tobacco—the staple products of Western Kentucky.

There are two sorts of soil to be distinguished within the limits of this property: that on the hills has, usually, a sandy composition, while that in the lowlands is, in a large measure, calcareous.

Although it is somewhat in advance of the regular order of the report, it seems proper at this place to call attention to the green and reddish marly shales, which are found on certain

parts of the estate or in the vicinity, overlying the great sandstone which occurs first above the massive limestone of the Sub-carboniferous series. These shales or marls are valuable, and are worthy of much consideration, as they bid fair to prove most admirable fertilizers for some of our impoverished tobacco lands. Their geological position is in the Chester Group, and they are found, wherever it is well developed, over a large portion of the western part of the State. They are undoubtedly destined to become quite valuable to Kentucky farmers, espècially to tobacco-growers; and it is possible that they may form the basis for a large manufacturing interest.

The marls are wonderfully rich in *potash* and *soda*, and for that reason they possess properties which, when their proper treatment shall be determined upon, should render them unexcelled for fertilizing worn-out tobacco lands. Tobacco extracts proportionately more potash than any other material from the soil; so that, in order to restore its former vigor to the soil, it becomes necessary to supply it with the substance in one of two ways: either with the potash in an uncombined condition, or with some mixture holding a large proportion of that material.

These marls may be used with benefit by simply spreading them thinly over the surface in the form that they are found in the bank, allowing the coating to remain on the ground throughout a winter, and then turning it in with the soil in the spring. It has also been suggested that they may be roasted in a kiln with lime. The advantage to be derived from such treatment would lie in the increased amount of potash, etc., that might then be taken from the mixture, within a certain time, by the simple atmospheric agencies, and mingled with the earth.*

Especial attention has been directed to these marls by Prof. Shaler and the chemists of the Survey. Should the experiments undertaken by Mr. Talbutt, for the purpose of testing

* For further discussion of the question, see the biennial report of the Director of the Survey.

the practicability of making the marl an article of commerce, prove successful, this point would be a desirable one from which to make shipments, being, as it is, within easy reach of water transportation. The marl beds are not distant more than two miles from the Ohio river, and may be found even nearer. At "Buffalo Lick," which, however, is not on this property, the marls are especially thick.

These marls are wonderfully alike in their composition, so far as yet known, wherever they are found in Western Kentucky. Unfortunately a sample of the marl in this region, although collected, was lost; but the following analysis, made by the chemists of the Survey, of a sample collected from Haycraft's Lick, Grayson county, will serve to show what may be expected from the marl in this region:*

COMPOSITION, DRIED AT 212° FAHRENHEIT.†

Alumina, iron, etc., oxides	27.811
Lime carbonate	.880
Magnesia	.824
Phosphoric acid	.109
Potash	5.554
Soda	.657
Water and loss	4.245
Silica and insoluble silicates	59.920
Total	100.000

According to the statement made by Captain William H. Pitts, there are already fifteen or twenty farms on the property of the company, each farm being provided with dwelling-houses and the necessary farm-yard buildings. The number of acres under cultivation was not learned.

TIMBER.

The larger portion of the property (that not under cultivation), is covered with a healthy growth of timber, including white oak, black oak, red oak, pin oak, and chestnut oak, poplar, ash, elm, sugar-tree, maple, linn, cherry, sweet gum, etc.

*Samples of the marl were placed on exhibition in the Kentucky Department of the International Exhibition at Philadelphia.

†The partial results of Mr. Talbutt's investigations have been made public through the columns of the *Kentucky Yeoman*, Frankfort, Kentucky.

This forest supply is an item of much importance, and should be duly regarded, as our forests of oaks (especially of the white and chestnut varieties) are yearly becoming more valuable. Considering the demand there is for timber at Evansville, Indiana, and at other points on the Ohio river, it seems remarkable that so little has been removed from this section.

III.

THE COAL, ETC.

As previously stated, the chief value of the property is derived from the bed of cannel coal which underlies certain parts of it. The cannel bed is not the only coal found on it, however; on the contrary, there is certainly one distinct bed of bituminous coal above the cannel bed—possibly more. There seem to be possibilities, also, that an iron ore of good quality is to be obtained on the land, or within a short distance of its limits. In examining a collection made by Major Atkinson, said to have been collected entirely on this property, samples of very admirable limonite, similar to the Subcarboniferous limonite worked in Trigg county, this State, were observed. No evidence, however, more trustworthy than this was obtained indicating the existence of any valuable ore deposits on the estate. It is not at all improbable that the specimen in Major Atkinson's collection was obtained in the ore region bordering the Cumberland river, and was present in the collection by a mistake.*

As originally written, an attempt was made in this report to give an approximate section of the more important beds in

*Since this report was written, this region has been examined by Mr. P. N. Moore—having come within the limits of his survey of the section along the eastern face of the coal field. It has accordingly been more thoroughly studied by him than by me; and the questions concerning the existence of ores in the region; of the form, height, and extent of the ridge, which has been mentioned on a preceding page, and the details of the structure of the ridge, are properly ones to be treated of in his report. It is to be hoped, also, that Mr. Moore's examinations, being more final in their nature than were mine, may have served to determine with accuracy the general character of the cannel bed; whether it preserves its condition as a cannel throughout its extent in this region, or merges into bituminous coal at some point beyond that reached by those openings that have been made in it at the mines; it may also have been possible for him to determine more definitely the extent of the bed, and hence the acreage of the coal. (April, 1877.)

the ridge which forms the central point of interest in the region. Subsequent considerations, however, have rendered it inexpedient to make the attempt a matter of record; accordingly, the following statement is an approximate section of only those beds underlying, and including, the cannel coal:

1. Cannel Coal . . . . . 22 inches to 3 feet 2 inches.
2. Sandstone and Shale, about . . . . . 40 "
3. Limestone and Shales ("Chester" beds), about . . . . . 110 "
4. Massive Sandstone (base of Chester Group), about . . . . . 60 "
5. Massive Limestone (St. Louis Group).

For want of an accurate map, it is impossible to locate the various coal outcrops.* Bituminous coal has been found at several localities on the estate. At present, however, the bituminous coal has little commercial value; but seems to serve more especially to indicate the probable presence of the cannel bed.

It is probable that no cannel, the "Boghead" of Scotland (which, in fact, is not a true cannel) excepted, has received more general attention than that which has been bestowed on the bed found in this region; its remarkable general character and its quality as a gas enricher have already been discussed in some detail in former geological reports on Kentucky, and in kindred works.

The coal is remarkably dense in structure and tenacious; vigorously resisting cross-fracture, although cleaving with tolerable facility in the direction of the laminæ. Its character is such, in fact, that the coal stands handling and weathering more than ordinarily well, sustaining thereby little loss in bulk either in mining or transportation.

In Gesner's work on coal oils† attention is drawn to the curious fact that, although analysis proves the Boghead cannel to have the largest per centage of volatile matters, the

*A map, prepared by a gentleman who had formerly examined these lands, was furnished me when in the region, and an attempt was made to use it when this report was originally prepared. Its imperfections are so apparent, however, that it has proved to be of little service. A correct map of the region has been made by Mr. Wm. Byrd Page, Topographical Assistant to the State Survey, in the course of the later investigations in the section, and may be issued at an early date. (April, 1877.)

†New York: Bailliere Brothers, 1865.

coal actually produces *less oil* than does the Breckinridge article.

The following is a comparison made by Gesner of the two coals: The Boghead cannel yields 120 gallons of crude oil to the ton, from which are obtained 65 gallons of illuminating oil, 7 gallons of paraffin oil, 12 pounds of paraffin—equal to about 84 gallons of marketable oils.

The Breckinridge coal yields 130 gallons of crude oil to the ton, from which are obtained 80 gallons of illuminating oil and 12 gallons of paraffin oil—making 92 gallons of marketable oils. Other products, such as aniline, benzole, etc., not uncommon to coals, are to be obtained from the cannel.

The extraordinary value of the coal for the manufacture of illuminating oil may be appreciated, when the fact is remembered that a coal which will yield 60 gallons of crude oil, or 40 gallons of refined oil to the ton, is regarded as an excellent article.

In fact, excepting the natural reservoirs of petroleum, the Breckinridge cannel undoubtedly offers one of the most productive sources yet known for the distillation of illuminating oils, and should it be necessary in the future to again manufacture our oil from coal, this article will be of very great value.

For the present, however, the especial and decided value of the coal depends upon its quality as a steam fuel and gas producer. This value is fairly indicated by the following analyses:*

*The differences between the analyses are probably, in a large degree, due to a difference in the samplings. The quality of any coal bed is variable according to the conditions existing in its various parts; to equalize this, by making an average of its quality as found at different parts of the bed, should be the aim of the one who takes the samples; this is very difficult to do in the case of cannel coal. Everything considered, the analyses do not compare unfavorably with each other.

Composition.	No. 1.	No. 2.	No. 3.
Moisture	1.30	1.44	.64
Volatile combustible matter	54.40	62.40	61.30
Fixed carbon	32.00	28.20	30.00
Ash	12.30	7.96	8.05
Total	100.00	100.00	99.99
Specific gravity	1.318	1.339	.....
Analyst	Peter.	Owen.	Gesner.

The amount of sulphur in Nos. 1 and 2 was undetermined; in No. 3 there was a trace.

These analyses (at least Nos. 1 and 2) were made quite a number of years ago; and the probabilities are, that in no case was an attempt made to procure fairly *averaged* samples of the coal—as was the case with the larger part of the tests made in those days to ascertain the quality of coals. The analyses were probably made from specimens which were collected without due regard being had for possible changes in the character of the bed at different places.

It is probable that, of the three analyses, No. 2 may be considered as the best fitted for general application. It is an average of *four* analyses made by Dr. D. D. Owen, and published in one of the volumes of his geological reports on Kentucky. Dr. Robert Peter mentions, in the report from which analysis No. 1 is taken, that the per centage of sulphur obtained in one air-dried sample of the coal was 2.433. This, however, is undoubtedly too high a per centage for the average amount of sulphur in the coal.

When this report was first written, the only available analyses of this coal (within my knowledge) were those which have been presented. Since then, however, an analysis, made by the chemists of the Survey, of a sample collected by myself, has been obtained. It is here presented, with the belief that it will be found to be a fairer indication of the *general* quality of the coal than any of those analyses previously given:*

* For the purpose of comparison, a set of analyses of other cannels is appended to this report.

Specific gravity	1.213	
Moisture	1.30	
Volatile combustible matter	59.60	
Fixed carbon	27.00	Coke 39.10.
Ash	12.10	
Total	100.00	
Sulphur, two determinations	1.890 and 1.903	

The quality of the coal as a gas *producer* is fully indicated by the above analysis, although the value of the gas, measured by its candle power, is yet to be determined. The fact of its great value as a producer of gas has also been proved by a practical test—considerable quantities of the coal having been at one time shipped to New York, and sold there at the rate of $15 and upwards the ton for enriching gas. It is in view to have photometric tests made of the gas produced from the coal, which, it is believed, will prove satisfactory.

IV.

THE EXTENT AND TONNAGE OF THE COAL.

An essentially important point to be determined in the inquiry concerning this coal is its acreage. The importance of a good map, showing the details of the topographical features of the lands, was very apparent when the reconnoissance was made. With the assistance of such a one as should be prepared, it would have been comparatively easy, it is believed, to lay down the area of the bed with some accuracy; but without it, especially since the examinations were not so thorough as would be desirable, all computations as to the acreage of the coal are necessarily *estimative*, and are to be regarded only as such.

From the testimony of others and from personal observations, it is believed that about 4,000 acres may be roughly assumed as the number which are, in all probability, underlaid by the coal; which would include an area of about six square miles.* In making this estimate the "Crawford" farm and

*It is very important for it to be understood that this estimate is based on the condition that the deposit is a true bed, and but little more subject to abrupt changes than is usually the case with coal beds. That this is true for the bed, *as a bed*, there is little doubt, at least so far as concerns this area; but the question concerning its constancy as a bed of cannel, whether at some places it may or may not merge into bituminous coal, is not considered. It must be borne in mind that the work was preliminary, and that the results are to be considered as preliminary to other work, hence on this point (especially), and kindred ones, the writer does not feel prepared to give his opinion unqualifiedly.

the "town property" (a total of 496 acres) are excluded; no coal will be found on the latter land, and very little is known concerning the former.

Whether this coal is to be found beyond the limits of this property is a question of much interest in the neighborhood. At present, any views in that connection must necessarily be based entirely on conjecture.* It may be well to quote, however, from the impressions recorded when this report was originally outlined: "Although unprepared with any absolute data concerning the question, the opinion that it may be found towards the southwest and west for a limited distance, provided the geographical conditions are favorable, may not be altogether improbable. There is undoubtedly a considerable gap in the extent of the bed beyond the boundaries of this property, and the quality of the coal may deteriorate—the bed may merge into bituminous coal. It is not probable that its quality will improve. The cannel does not seem to extend very far in any direction beyond the boundaries of the particular section under consideration, as the coal found elsewhere, which is thought to occupy the same relative position as the cannel bed in this district, is of the 'bituminous' kind."†

The thickness of the coal varies from twenty-two inches to thirty-eight inches, and the bed is reported to have occasionally measured forty-four inches in thickness. It is, therefore, a difficult matter to accurately determine the number of tons of coal to the acre. It is stated by trustworthy men, that the thickness of the bed is oftener three feet than two feet; it seems more prudent, however, to underrate than to overestimate the tonnage; accordingly, the average of the measurements (two and a half feet) is used as the basis for calculation.

* The truth of this was particularly impressed upon me by a journey made from Cloverport to Hawesville in the spring of 1876. At this time it seems extremely improbable that the bed, as a cannel coal, extends much beyond the west limits of the Cloverport Coal and Oil Company's property. (April, 1877.)

† For more specific information on this point, the reader is referred to Mr. Moore's forthcoming report on this region. The more accurate results obtained by him in his study of the district may have been sufficient to determine the full extent of the bed, and to solve the questions concerning its general character. (April, 1877.)

With a specific gravity of 1.213, which is the specific gravity indicated by the analysis of the samples analyzed by the chemists of the present Survey (see page 14), a thickness of 2½ feet would produce 3,685.7 tons to the acre, or 14,742,800 tons for the 4,000 acres (using the ton of 2,240 pounds), should that area prove to be underlaid by the cannel. Assuming a smaller acreage for the coal, however—for instance 3,250 acres—the result would be 14,374,230 tons, measuring the thickness of the bed at 3 feet; which, under the circumstances, would seem allowable. According to this computation, the coal would last for 287 years, with an annual output of 50,000 tons.*

V.

THE COST OF PRODUCTION.

The present price paid for mining is one ($1) dollar the ton *to the miner*. To this may be added seventy-five cents the ton to cover all additional expense incurred in removing the coal from the mine and placing it on barges on the Ohio river at Cloverport.

The towage to New Orleans, so I am informed by coal-shippers, may be placed with safety at not more than seventy-five cents the ton. Should the mine-owners have their own barges and tugs, however, the freightage would be less.

The total cost per ton of the coal, when arrived at New Orleans, may then be represented thus:

Amount paid for mining	$1 00
Amount paid for removing from mine and placing on barges	75
Towage to New Orleans	75
Assumed amount to cover all incidental expenses—insurance, etc.	50
Total cost, delivered at New Orleans	$3 00

* Without the aid of a large number of determinations of the specific gravity, there is always a certain degree of approximation which enters into the calculations for the tonnage of coal—even when a certain thickness of the bed is assured. When this report was first prepared, the only analyses to be obtained of this coal were those presented on page 13, and 1.339 was taken as the specific gravity—that being the result of four determinations by Dr. D. D. Owen. It is deemed proper, therefore, to present the calculations based on that determination, as they were embodied in the original report. With a specific gravity of 1.339, a thickness of 2½ feet of coal would produce a fraction more than 4,023 tons to the acre, or 16,095,658 tons for 4,000 acres. Assuming 3 feet as the thickness of the bed, 3,250 acres would produce 15,833,250 tons of coal; and, according to this calculation, the coal would last 316 years, with a yearly yield of 50,000 tons.

The cost of handling and selling the coal at New Orleans was not learned. It may be confidently estimated, however, that $3.25 the ton will fully cover all manner of expenses which may be incurred in mining and vending the coal. It is not improbable, indeed, that it is an overestimate.

The cost of carriage from New Orleans to Liverpool was not definitely learned. It is believed, however, judging from information received from Mr. Wm. Creevy, of New Orleans, that, at certain seasons of the year, the coal may be landed at Liverpool, direct from the mines, at a total cost of from $5.25 to $6.25 the ton—possibly less.

It does not seem at all necessary, however, to look to England for the disposition of the coal. There is no reason why all that may be mined in a year may not be sold in this country—in the towns lying along the Mississippi river, in New Orleans, and in New York. In fact, its quality as a gas producer is such that, were it placed in the market, New York alone should consume a large proportion of the output.

ESTIMATES FOR THE INCOME.*

The coal may be carried to New York *via* New Orleans at a cost of about $5.00 the ton from New Orleans, or $8.25 the ton direct from the mines (including the cost of mining, etc.), and sold there for from $10.00 to $15.00 the ton—an average of $12.50.†

Were all the coal sold at the rate of $12.50 the ton, which is believed to be rather under than above an average price, there would be a net profit of $4.25 per ton. Multiplying this by 50,000, the assumed number of tons vended in a year, we obtain $212,500 as the annual income from the coal alone.

This simplified reads:

Gross returns from 50,000 tons, at $12.50 the ton	$625,000
Less cost, at $8.25 the ton	412,500
Total annual profit	$212,500

*This is a matter which is entirely estimative, and is of more value as a graphic illustration of the possibilities of the estate than as a strict mathematical fact. The estimate was made at the request of Col. Johnston.

†These prices fluctuate, of course; but a careful comparison of many "prices current" reports justifies this estimate.

To this may be added rental from some fifteen or twenty farms; not knowing the amount of income from them, however, it is not taken into consideration. Appended to this report is a letter from Mr. Creevy, of New Orleans, giving further information concerning the market price of cannel coal in Liverpool, New Orleans, and New York.*

Just at what sum the property is valued I am not informed. Supposing, however, that a capital of $500,000 be raised for its purchase, with the expectation of the purchaser recovering the amount in twenty-five years, the following would exhibit about the amount on which a yearly dividend might be declared:

Annual income from 50,000 tons of coal	$212,500
Less amount to be set aside annually (bearing interest at 6 per cent.) to reinstate the capital—about	18,875
Net income	$193,625

This would be about 38.7 per cent. on the original capital.†

VI.

THE MINES.

The mines from which the coal used by the Breckinridge Coal and Oil Company was taken are located near the centre of the property, at Bennettsville—the name given to the mining village about eight miles southwardly from Cloverport.

There are at this place eleven dwellings worthy of restoration; to do which would cost, on an average, $200 to each house—making a total of $2,200 as the cost for repairing the eleven.‡ In addition to these dwellings, there are (at the mines) an engine-house, in good order, with stalls for two engines; an office, a scales-house, a large building used for a school-house and "lodge-room," and a barn and stables for the bank mules.‡

At the factories, on the river, there is a cottage used by the superintendent, valued at $2,500; a tenement row, valued at

*See Appendix "A."

†The actual amount of coal mined in a year may, and very probably would, fall very short of 50,000 tons. It will be understood that such a basis for calculation is used altogether for convenience, the actual yield being determined entirely by circumstances.

‡See Appendix "B."

$5,000; and "Cairn's Castle" (a dwelling which cost in its unfinished condition $11,000), valued at $5,000. The remaining buildings and materials are, under the circumstances, valued at no more than $2,000.

The mines were connected with the river by a broad-gauge railway, seven and a half miles in length. The line is now in a very poor condition, the trestling and cross-ties having rotted away. The road-bed, however, is in comparatively good order, requiring but little work to make it ready for a narrow-gauge track. The track as originally constructed was a poor affair, consisting merely of wooden stringers, banded with iron, laid across the cross-ties. It will be seen that the estimate for rebuilding the road calls for no articles but those of the best quality.*

The mines consisted of sixteen (16) adits driven in the hill high above water level; only one is now working, and that chiefly for the purpose of supplying steamboats with coal for torches, etc. Taking into consideration the length of time they have lain without attention (nearly fifteen years), the entries are in a fair condition; many of them, so far as may be seen, needing but little work to reopen them. Some, however, are choked up with débris which conceals their interior condition. As the roof is a sand rock, however, it is believed that most of the material has come from near the entrance, and that further back the entries are comparatively clear. Water was standing in nearly all of the drifts (except the one now working), kept there by the banked up débris at their mouths. From all that could be gathered concerning it, it would seem that the question of drainage is of small moment, as the entries are so located that they may be kept clear of water with comparative ease.

THE COST OF REOPENING THE ENTRIES, ETC.

The cost of reopening the mines and arranging everything in working order once more would be about as follows:†

*See Appendix "C."

†See Appendix "C" in part.

Reopening fourteen entries, at $100 each	$1,400
One hundred bank cars restored	1,500
One pair track scales	1,000
Repairing incline and drum-house	1,500
Repairing ten houses at the mines	2,000
Hoisting engine and rigging for drum-house	4,500
Re-establishing the railroad	83,617
Incidentals	1,000
Total	$96,517

Reference is made to the careful estimate prepared by Captain William H. Pitts, which is appended to this report, for the details required in rebuilding the railroad.

In conclusion, it may be stated that, although this statement may seem crude in some of its parts—due in a large measure to the limited time that was allowed wherein to collect data—it has been the endeavor to give no more than simple facts concerning the property. I was not so fortunate in obtaining estimates as was desired and expected; accordingly, those given may not be so complete as possibly may be generally desired.

APPENDICES.

APPENDIX A.

LETTER FROM WILLIAM CREEVY, ESQ.

"NEW ORLEANS, October 19th, 1875.

"DEAR SIR: * * * * With regard to the selling price of coal in England, would say that it varies very much, as there are such a variety of qualities. The article known as 'English Cannel,' which assimilates very much in character to the 'Breckinridge,' sells at 16 sh. and 20 sh. per ton; and freight from Liverpool ranges from 12 sh. to 15 sh. per ton. The article is not in general use in this market on account of the price; it usually commands $12 to $15 per ton. With regard to the cost of transportation of coal to England, would remark, that I have never known a shipment from this country, although freight could doubtless be had at some seasons of the year, for the purpose of ballast, at $2 and $3 per ton.

"While agent for the 'Breckinridge Coal Company,' in 1853–'6, I shipped several cargoes of the coal to New York, at freight of $5 per ton; and the coal sold in that market for fuel purposes and as enricher of gas for $15 per ton and upwards.

"Since 1857, no Breckinridge coal was received at this point, and, in fact, no shipments were made from the mines. The company considered the coal too valuable for fuel purposes, and their attention was given to the manufacture of oil, etc. The coal in this market commands about the same price as English cannel, and I sold large quantities at $10, and in some instances, when the stock of coal was low, at $12 and $15 per ton.

"This market is now almost exclusively supplied with Pittsburgh coal, and the consumption of last year was put at 375,317 tons. The price depends very much on the supply, which is governed by the stage of water in the Ohio river. The average price for the past two years, at wholesale, about $4 per ton; at retail, about $6.50 and $7 per ton.

"Having lost all the books and memoranda connected with my agency of the 'Breckinridge Coal Company,' I am unable to furnish you with particulars. * * * * *

"Yours truly,

[Signed] "WM. CREEVY."

APPENDIX B.

LETTER FROM CAPTAIN WM. H. PITTS.

"CLOVERPORT, KY., September 24th, 1875.

"*Mr. C. J. Norwood:*

"DEAR SIR: I am in receipt of your favor of the 20th inst., and respond just as soon as I have been able to obtain answers to some of your questions; and regret that I can offer but meagre information.

"As regards your first question,* I can give you no figures. Major Atkinson and myself both endeavored last year to get data upon which to base an estimate of the amount taken from the mines, but such information as we did get was obtained by leading questions put to parties whose answers I considered only guess-work, although Major Atkinson made therefrom a map, which should be with those you have, and will give you as accurate an idea as anything I can give you.† You saw the condition the entries were in, and will readily see that at present a survey cannot be made.

"A list of articles at the oil works would require the work of two men a number of days to make, and avail little after it is made. The value of such old material as now remains is simply the amount it would bring if sold as such. All the carpenters here are, at present, engaged in the construction of a large tobacco warehouse, and I have not been able to get one of them to go to Bennettsville to make the estimate you desire; besides, I do not think any one of them is capable of giving an accurate opinion about the repairs necessary.

*This concerned the amount of coal that had been removed from the mines.—C. J. N.

†This map I found to be not of very practical value.—C. J. N.

"There remain at the mines, at present, some eleven dwelling-houses worthy of restoration. Three of these are occupied, and I believe, as an average, less than $200 each will place them in good repair. Besides these there is an engine-house, with stalls for two engines, which is in good order; also an office, scales-house, a large building used as a school-house and lodge-room, and a barn and stables for the bank mules.

"The Superintendent's cottage is valued at $2,500; the tenement row was only partially finished originally; now some seven of them are worth say $500 each, and as many more $300 a-piece. The other buildings at the works are not adapted to other use than the one they were intended for, and I therefore think, in view of their present condition, they are most valuable as old material, and as such are probably worth $2,000. The building known as the 'Castle' was not entirely finished when the work upon it was suspended; up to that time it had cost $11,000, I am told. Although it might not sell for so much, I believe it is worth $5,000 to any one who could spend $2,000 in repairs to it.

"In addition to the coal lands, of which you have maps and areas, the company owns the right of way for a railroad from Bennettsville to Cloverport, some seven miles in length, and fifty feet on each side of the centre line of the road.

"At the river there are some twenty-seven acres of land, to which must be added the castle lot, containing eight more. There are some fifteen or twenty farms in the outlying lands, the buildings upon which are log-houses, with necessary barns and outbuildings, the value of which we cannot estimate.

"There has never been a survey made of the cultivated lands, and I can't tell the number of acres they contain, nor have I had time to go and make an approximation.

"Since receiving your letter, I have talked with several miners, and they all agree in saying that, on the eight hour system, one ton per day to the man is about as much as can be relied upon for each miner to average.

"The price I am now paying is $1.60 per ton, the miner delivering the coal outside. I send you inclosed a copy of the railroad estimate; you will find therein some answers to your questions.

"The gauge of the old road was four feet eleven inches, and of course any one under this can be adopted, and will not change materially the aggregate amount.

"The prices affixed for iron, spikes, cars, engine, etc., are quotations from reliable firms, and are of late date; and the other prices are rather over than under, and everything to be first-class of its kind. There are one or two items omitted, for the reason that we can supply them from what we have on hand.

"Regretting my inability to give you more accurate answers, * * * * * * *

"Respectfully yours,

[Signed] "WM. H. PITTS."

APPENDIX C.

ESTIMATE OF COST OF RE-ESTABLISHING THE CLOVERPORT COAL AND OIL COMPANY'S RAILROAD, ETC.

8 miles grading, ditching, and surfacing, at $500 per mile	$4,000
19,000 cross ties, at 20 cents each	3,800
17,000 cubic yards of stone ballast	8,500
3,700 lineal feet of trestling, at $3 per lineal foot	11,100
43 culverts restored, at $50 each	2,150
380 tons T rails, 30 lbs. per yard, at $56 per ton	21,280
3,168 fish-bar joints, at 60 cents each	1,908
297 kegs of rail spikes, at $7 per keg	2,079
35 coal cars, at $200 each	7,000
2 flat cars repaired, at $200 each	400
1 locomotive engine, delivered	7,500
100 bank cars restored, at $15	1,500
2 turn-tables	1,500
Laying track	1,500
Water-tanks	1,900
Track scales	1,000
Repairing incline and drum-house	1,500
Reopening entries to mines, at $100 each	1,400
Repairing 10 houses at mines, at $200 each	2,000
Engineering expenses	3,000
Engineering instruments, stationery, etc.	1,000
Contingencies, freights, etc.	5,000
Total	$91,017

[Signed] WILLIAM H. PITTS, C. E.

APPENDIX D.

TABLE OF SPECIFIC GRAVITIES OF COAL, WITH COMPUTATIONS FOR THE CORRESPONDING NUMBER OF TONS IN ONE ACRE AND ONE HUNDRED ACRES.* PREPARED BY C. J. NORWOOD.

Specific gravity.	1 acre.	100 acres.	Specific gravity.	1 acre.	100 acres.
1.01	1,227.55	122,755	1.21	1,470.63	147,063
1.02	1,239.70	123,970	1.22	1,482.78	148,278
1.03	1,251.86	125,186	1.23	1,494.94	149,494
1.04	1,264.01	126,401	1.24	1,507.09	150,709
1.05	1,276.17	127,617	1.25	1,519.25	151,925
1.06	1,288.32	128,832	1.26	1,531.40	153,140
1.07	1,300.47	130,047	1.27	1,543.55	154,355
1.08	1,312.63	131,263	1.28	1,555.71	155,571
1.09	1,324.78	132,478	1.29	1,567.86	156,786
1.10	1,336.94	133,694	1.30	1,580.02	158,002
1.11	1,349.09	134,909	1.31	1,592.17	159,217
1.12	1,361.24	136,124	1.32	1,604.32	160,432
1.13	1,373.40	137,340	1.33	1,616.48	161,648
1.14	1,385.55	138,555	1.34	1,628.63	162,863
1.15	1,397.71	139,771	1.35	1,640.79	164,079
1.16	1,409.86	140,986	1.36	1,652.94	165,294
1.17	1,422.01	142,201	1.37	1,665.09	166,509
1.18	1,434.17	143,417	1.38	1,677.25	167,725
1.19	1,446.32	144,632	1.39	1,689.40	168,940
1.20	1,458.48	145,848	1.40	1,701.56	170,156

APPENDIX E.

ANALYSES OF VARIOUS CANNEL COALS.

Following are analyses of several cannel coals, some of them being well-known ones, for comparison with those made of the Breckinridge coal:

Number of analysis	1	2	3	4
Moisture	1.50	1.20	3.53	0.94
Volatile combustible matter	52.20	58.80	48.30	52.38
Fixed carbon	40.60	35.30	42.39	35.54
Ash	5.70	4.70	5.78	11.14
Total	100.00	100.00	100.00	100.00
Coke	46.30	40.00	48.17	46.68
Sulphur	0.780	not est.	not est.	1.423
Specific gravity	1.306	1.180	not est.	1.280
Analyst	P. and T.	P. and T.	C. and B.	P. and T.

*The thickness of the coal is reckoned at one foot, and the ton used is the one of 2,240 pounds. The table will also serve for other materials than coal.

Number of analysis	5	6	7	8
Volatile matter*	43.37	49.6	70.10	58.52
Fixed carbon	46.50	41.3	10.30	25.28
Ash	10.13	9.1	19.60	14.25
Total	100.00	100.0	100.00	98.45
Specific gravity	1.27	1.228	not est.	1.1831
Analyst	Johnson.	. . . . .	Gesner.	. . . . .

*Includes "moisture." Sulphur not determined.

Analysis No. 1 is of the "Hunnewell" cannel, Kentucky; No. 2, Frozen Creek cannel, Breathitt county, Kentucky; No. 3, Saline county, Missouri, cannel (used at the St. Louis gas works), analyzed by Chauvenet and Blair; No. 4, George's Branch cannel, Breathitt county, Kentucky; No. 5, Kanawha cannel, Virginia; No. 6, Lesmahago cannel, Scotland; No. 7, Boghead cannel; No. 8, Weym's cannel.

All analyses indicated as made by "P. and T." were made by Dr. Robert Peter and Mr. John H. Talbutt, Chemists for the Geological Survey.

For proper comparison with the last four analyses, it should be remembered that the total volatile matter indicated in the analysis of the Breckinridge coal amounts to 60.90 per cent., or 9.20 per cent. less than in the Boghead cannel coal.

GEOLOGICAL SURVEY OF KENTUCKY.

N. S. SHALER, DIRECTOR.

REPORT

ON THE

TIMBERS OF THE NORTH CUMBERLAND: BELL AND HARLAN COUNTIES.

BY LAFAYETTE H. DEFRIESE.

PART IX. VOL. IV. SECOND SERIES.

STEREOTYPED FOR THE SURVEY BY MAJOR, JOHNSTON & BARRETT, YEOMAN PRESS, FRANKFORT, KY.

365 & 366

INTRODUCTORY LETTER.

Professor N. S. SHALER, *Director Kentucky Geological Survey:*

DEAR SIR: I herewith send you a report on the timbers of the North Cumberland, which is a continuation, both in method and purpose, of a previous report on the timbers of four counties of Western Kentucky. The study upon which the present report is based was made during July and August, 1876, and was sufficiently exhaustive to insure accuracy and a reasonable degree of completeness.

Very respectfully,

LAFAYETTE H. DEFRIESE.

NEW YORK, March 20, 1877.

REPORT ON THE TIMBERS OF THE NORTH CUMBERLAND—BELL AND HARLAN COUNTIES.

The method of study pursued in investigating the timber of the North Cumberland necessarily differed somewhat from that indicated in a former report on the timbers of Grayson, Breckinridge, Hancock, and Ohio counties.* The reason is, that the latter counties are comparatively level, are largely settled, and their timbers had to be studied with reference to the effects which clearing away the old forests would have upon the future timber growth of the counties. In the present report, on the contrary, the country is almost impassably mountainous; comparatively a very small proportion of land has been cleared, and the mountains are still crowned by their vast and primitive growths. The end to be attained in this report is, evidently, to give a conception as clear as possible of the present condition of these timbers. I have, therefore, not done so much plotting of ground and numbering of trees as was given in the former report; for it is manifestly very difficult, if not impossible, for the mind to pass from the consideration of a few detached and poorly representative plots of ground, of a few hundred square yards each, to the comprehension of a vast forest whose area comprehends millions of acres.

Another difficulty lies in the way of giving a clear impression of the timbers under discussion. They grow upon a perfect net-work of mountains. There is no regular gradation of timbers on these mountain chains; so no fairly representative one can be chosen and studied which will give data for a report upon, and a clear comprehension of, the whole. On the contrary, the mountains are sharply divided into those whose forest must rank among the finest in this or any other coun-

*See report on the timbers of those counties in volume II of this series.

try and those whose timbers are, at best, only tolerably good, often mediocre. There are no intermediate chains. To the former class belong the Black Mountain and its spurs; to the latter class, the Brush, Pine, and Cumberland mountains. I tried to find out the reason of this extraordinary difference in the timbers of mountain ranges which are all intermingled, and whose geological composition is essentially the same. My opinion is, that the difference is due to the position of the underlying rocks. In the Pine, Cumberland, and Brush mountains these rocks have an average dip of 14° to 25°. The result is, that in passing up one face of the mountain we climb directly up the dip, which so nearly coincides with the slope of the mountain that the beating of summer rains and the action of winter snows keep the soil washed off nearly down to the rocks themselves, leaving no ground for the roots of a massive forest growth to take hold and flourish in. The result is a stunted growth of hardy trees, whose roots are spread out on the surface of the barely covered rock below, such as mountain chestnut oak and rather small sizes of chestnut, red oak, pin oak, and the various pines. On going down the opposite side of these mountains, the continual masses of outcropping rocks, forming a steep and precipitous descent, leave no room for other timbers than the *Rhododendron* (wild rose bay), *Kalmia latifolia* (American laurel), and such shrubs as cling to the faces of rocky cliffs.

On the Black Mountain and its spurs, on the other hand, the rocks are horizontal, and the slowly accumulating detritus clings to their surfaces, whose position opposes the slope of the mountain at such an angle as to hold the detritus in place. A loose soil accumulates, in which an abundance of forest weeds spring up, and the decay of leaves and of these annually dying weed-tops constantly adds richness and depth to the soil already in position. The consequence is, that, in the parts of the Black Mountains familiar to me, even on the steepest slopes, there is a rich alluvial soil of from two to four feet in depth. For this reason, there is a growth of chestnut, tulip tree (yellow poplar), black walnut, white and

blue ash, birch, linden, and white hickory, that I have never seen surpassed.

As no mountain could be chosen for study which would fairly represent the timber of the country, my method was to make sections across Black Mountain and its spurs, and also across Brush and Pine Mountains. I chose some as nearly representative locality as possible at which to cross the mountains, and at every hundred barometric feet in height, more or less, I noted the proportion, size, and condition of growth of all the timber distinctly visible from that point. This method will, of course, give the height above drainage at which any species disappears or is introduced. I tried also to get the proportional effects of alluvial soil and of nearness to water upon what are known as swamp timbers. It is well known that some timbers are found only on bottom lands, and never appear very high above water-level; but, whether this fact is due more to the presence of the detritus from the hills, which always forms an alluvial soil along the streams, or whether the presence of water is absolutely essential to their growth, I was not able to determine. In the former case, the same timbers would grow on such soils, whether close to water or not. An experiment, showing whether these swamp timbers will grow on alluvial soils high above water, or whether they will grow near water without an alluvial soil, would be very interesting. My own opinion is, that the soil, not the water, is the essential part with most of them. I was led to this opinion by noticing that little benches, high up on the mountains, where there is no constant drainage, but where deep alluvial soil has accumulated, grew most of the swamp timbers; but, as a certain amount of water always found its way during rains into these depressions, it was impossible to get data enough to warrant more than a mere conjecture.

In regard to the relation between the old and the young forest growths in this region, with the exception of walnut timber and of other timbers in certain localities, I see no reason why the present proportions between the two should be materially changed in the near future.

The walnut timber is as ruthlessly destroyed in Eastern as in Western Kentucky. I saw a magnificent walnut tree, forty inches in diameter, with a trunk of more than fifty feet in length, cut for rails—a tree worth hundreds of dollars sacrificed for a few panels of fence. No care whatever is taken either to preserve the old forest walnut now standing or to encourage the young growth. Besides this, except in certain localities, there is a practice of yearly "burning off the woods," which is doing almost irreparable injury to the forests in those parts of Black and Brush mountains where the timbers are finest. Especially in the Black Mountains, there is a very heavy growth of weeds that yearly die down, and, with the fallen leaves, make a perfect mass of highly combustible material. Late in the fall, when these are driest, they are set on fire, and the heat is great enough to kill every bush that has appeared during the year. As this is done year after year, there is no chance whatever for a young forest growth to start. The consequence is, that in those parts of Black Mountains where the present forests are most dense and valuable, there is not a single young tree or bush to be found. In many places this practice has been going on so long that the old forest is rapidly dying out with age, and there is nothing coming on to take its place. If the practice of burning off the mountains is not stopped immediately, at any rate long enough for a new forest to get a permanent hold, so that fire cannot destroy it, before many years a mountain as rich in valuable timbers as any I know of in this country will be almost, if not entirely, stripped of its precious products. Some extra care should certainly be taken to preserve and perpetuate so rich a forest of such timbers as black walnut, black, white, and blue ash, white hickory, tulip tree, black birch, etc. So valuable are the ashes and the white hickory now becoming, that a Paris carriage manufacturing firm is thinking seriously of establishing a spoke factory in some part of Kentucky, where these timbers can be most easily obtained. Already there is a very large trade going on in *Liriodendron* or tulip tree (called yellow poplar) timber,

logs of which are cut from the mountains and floated down the Cumberland in immense numbers every winter. However, I see no reason to apprehend any near exhaustion of this timber, if more care is taken to prevent the killing of the young growths by fire, which certainly should be done. At least a dozen species of the most valuable timbers in the markets of the world now grow in large quantities on the Black Mountain ridges. Their extinction would be even more than a State calamity. In fact, Kentucky alone might, at the expense of a few hundred dollars, have exhibited at Philadelphia, in 1876, a collection of timbers which would have rivaled the timber exhibit of any foreign country in the quality, variety, and value of its woods.

I deem it best, before commencing a more minute consideration of the effect of different soils, height above drainage, etc., upon different timbers, to refer generally to some peculiarities that struck me, in the distribution and growth of certain varieties of trees. As black walnut is the most valuable of the timbers, I shall commence with that. I made a section across Black Mountain, starting on the Cumberland river, at Hezekiah Hall's, not far from the dividing line between Bell and Harlan counties. My barometer, at the starting point, stood 1,870. At a height of about 1,300 barometric feet above the datum point, and about 500 barometric feet below the crest of the mountain, I found a remarkable belt of the finest old-forest walnut timber that I have ever seen. The trees are more scattering now in this belt than they have been; for the trunks of several of the finest, which had fallen during the year, were still lying there. There is no undergrowth of any kind whatever to be found within the compass of this belt, owing to the practice before mentioned of burning off the woods yearly. The belt to which the walnut timber is almost wholly confined here, is only of the width covered by a height of a little more than 100 barometric feet; that is, at the lower edge of the belt my barometer registered about 3,100, and at the upper edge about 3,240. On a steep mountain side this forms a very narrow strip of ground. About

300 barometric feet below this walnut belt I noted a bed of outcropping coal sixteen inches thick. The walnut itself is growing on a very rich loamy soil, partly detritus and partly decayed vegetable matter, about two feet deep, almost entirely devoid of undergrowth of trees, but perfectly matted with a rank growth of forest weeds, fully ten feet high in places. This walnut-growing belt winds along the mountain as far as I had time to trace it (which was not very far, however), always at about the same height above the river below. I noticed that it was just under the top crest of the mountain, and crossed precisely at the heads of the various little streams that flowed from under that crest and made their way to the river below. One of the many magnificent walnut trees that I found in this peculiar belt was fourteen feet six inches in circumference, with a curling but straight and beautiful trunk, sixty feet in length. In an area of twelve hundred and fifty square yards in this belt the principal timbers were:

Black walnut	6;	average diameter	40 inches.
Buckeye	5;	"	29 "
White ash	3;	one of them with diameter	34 "
Linden	6;	average diameter	23 "

But this plot of ground was a choice one. There is not such an average of walnut as that even in the belt here spoken of.

Another case of peculiarity in the growth of certain timbers which I noted, is that of the hemlock (*Abies canadensis*) of Eastern Kentucky. In this part of the country the hemlock is confined wholly, so far as I know, to Conglomerate formations; so that the presence of this timber, in any locality in this part of Kentucky, is a guarantee that the geological formation there is Conglomerate. Of course, in other parts of the country, hemlock grows on other than Conglomerate soils; and of course, too, not all Conglomerate soils of Kentucky grow hemlock. Through all the coal regions of Western Kentucky I never saw a single tree of it. But not only is the hemlock of Eastern Kentucky confined to Conglomerate formations; it is also never found very high above local drainage. In the whole course of Cumberland river, from Cumberland Gap to near its head waters, and on all the

various small streams that rise in Brush, Black, Pine, and Cumberland mountains, and flow into Cumberland river, I have never seen a single hemlock more than one hundred barometric feet above local drainage, except in one spot. That was shortly after crossing the Harlan county line in ascending the Cumberland, where I found some hemlock trees on top of the bluff, that here rises precipitately from the river to a height of two hundred feet. But even in this case, although the trees are two hundred barometric feet above the river, on the opposite side of the hemlock from the river is a considerable depression, through which a branch runs most, if not all, of the year; so that this is not strictly an exception to the statement that I never saw a hemlock, in this part of Kentucky, growing more than one hundred feet above local drainage. So far as my observation extends, therefore, the presence of a hemlock tree in Kentucky proves two things: Conglomerate formation, and water, present part of the year at least, within one hundred barometric feet.

The last peculiarity of growth that I shall notice here, is that of the white oak. In a former report on the timbers of some parts of Western Kentucky (volume II, page 339) I mentioned the want of hardihood in the white oak, inferred from the fact that Spanish oak, red oak, pin oak, etc., when left to free competition with the white oak, in the course of time choke it out and supplant it. In Eastern Kentucky, where the mountains are sufficiently high for exposure to different points of the compass to produce a marked effect on the timbers, I found a confirmation of my former opinion in regard to the comparative sensitiveness of the white oak. In making a section across Black Mountain, along what is called Hall's branch, not far from the Harlan county line, the hills on either side of the hollow are quite steep and high, and form a synclinal, one face of which is exposed to the north, the other to the south. The formation and soil of the two faces were exactly the same, so far as I could see, and both were heavily timbered. But on the hillside exposed to the south about forty-five per cent. of the whole timber was of

the most massive and splendid white oak, often four feet in diameter and ninety feet high. Here there was less than one per cent. of *Liriodendron* (yellow poplar, so-called). On the northern exposure opposite, on the contrary, about thirty-five per cent. of the timber was massive *Liriodendron*, many trees of which were six and seven feet in diameter, with trunks sixty to eighty feet high. Here the white oak formed less than one per cent. Of course this is a very striking example, and it could not be said that difference of exposure everywhere in these mountains produces such a marked effect upon the white oak. But altogether, my observations convinced me beyond a doubt that the white oak is not so hardy a tree as it is often supposed to be.

There are not many valuable timbers in Eastern Kentucky which I have not already noticed in a former report on Western Kentucky timbers. Of course the black walnut, already noticed, and the black birch, of which there is a considerable quantity scattered through the Black and Brush Mountains, are the most valuable timbers. But, as in Western Kentucky, the people seem to attach very little importance to either. The *Liriodendron* is largely floated out every winter, as I mentioned before, for lumber. The white hickory and black and blue ash rank next in value; and they all abound, in the Black Mountain especially. Owing to the abundance of water-power, the accessibility, in large quantities, of these timbers, and their great demand in carriage-making, I see no reason why the near future should not see many spoke factories, ax-handle and hammer-handle factories, and carriage factories, in this part of Kentucky. Already the eyes of some large carriage factories are turning toward these timbers, and they only need to be better known in order to become a good source of revenue to the people. The red maple, which is growing more and more into favor in cabinet work, also abounds in Bell and Harlan counties. The linden (*Silia Americana*) is also found in large quantities through these mountains, and is very valuable in cabinet work, paneling, etc. The pines, especially the pitch pine (*Pinus rigida*)

and the yellow pine (*Pinus mitis*), are very abundant in parts of the mountains, particularly Pine Mountain. They are too well known to need especial mention, except to say that not a pine is to be found in those counties of Western Kentucky, on which my former report was made, so far as I could discover. I know of no especial reason for their total absence from that part of Kentucky. Certainly the want of mountains in Western Kentucky is not a sufficient explanation; for pine woods are often low and flat, though I do not know of any in Kentucky that are so. Other timbers found in Eastern Kentucky, that do not grow in such parts of Western Kentucky as I have studied, are the magnolias (*Magnolia acuminata*, *M. umbrella*, and *M. fraseri*), hemlock, *Rhododendron* (*maximum*), and American laurel (*Kalmia latifolia*).

I shall now proceed to give in detail the most important of the sections made, in the order in which they were made. Between ten miles above Pineville and Browning creek the exposure of the mountain facing the river shows *Liriodendron*, hemlock, beeches, chestnut, red oak (called often water oak by the people), the three magnolias given above, *Rhododendron* (*maximum*), American laurel, red and white maple, trident red maple, white oak, pines (*mitis* and *rigida*), the various hickories (mostly shell-bark), dogwood, sourwood, and Stuartia (*Stuartia virginica*).

A section was made up Browning creek to Brush Mountain, and across Brush Mountain to Cumberland Mountain. Up Browning creek, to the last crossing before starting up Brush Mountain, the timbers noted were white oak (which predominates), pin oak, pig hickory, chestnut oak, mulberry, red elm, buckeye, papaw, sycamore, shag hickory, white walnut (in considerable quantities), black walnut (small quantity), white ash (very fine and large), grey birch, linden (*Tilia Americana* and *T. heterophylla alba*), white elm, black cherry (only one or two), winged elm, white hickory, the magnolias, hemlock, sweet gum, and black sumach. I should say here that, in making sections through the mountains, I give the timbers, not in the order in which they probably predominate, but in

the order in which they are met with. This is very necessary, especially in going up a steep mountain side, as it marks the height above drainage at which different timbers grow.

In starting up Brush Mountain, the timbers remained substantially the same for a barometric height of four hundred and sixty feet. They are the magnolias, chestnut, hemlock (for the first fifty feet only), black gum, white oak, white maple, beech, tulip tree, black hickory, grey birch, black oak, pin oak, red oak, white hickory, sycamore (along Middle Branch), black walnut (in small quantities), white walnut, holly, black locust, red elm, shag hickory, and red maple (very large). The formation is conglomerate. At a height of four hundred and sixty feet chestnut oak is first seen. There are also black ash, red oak, witch hazel, and scattering pines.

Timbers.	Height in barometric feet.	Remarks.
Pines, chestnut, chestnut oak, black gum, and rock maple .	720	The absence of all the other timbers here is due not so much to height as to vicinity of a slide, which had precipitated the crest of the mountain down to nearly this height.
Pines (*P. mitis* and *P. rigida*) . .	965	Here we come to a bluff that has fallen from the top of the mountain, and hence the absence of all timber except dwarf pines. This throw lasts for a height of three hundred feet.
Black locust, chestnut, chestnut oak, black birch, magnolia cucumber, pin oak, *Liriodendron*, sweet pepper, etc.	1300	At this height the fall from the mountain top is crossed, and we again find the timbers that normally belong to the mountain side. All of these timbers are very heavy.
Chestnut oak almost entirely . .	1600	Here we meet with another slide from the mountain top, which normally belongs just below the one at a height of 965 feet. Very evidently that was originally the mountain crest, and fell first. This underlay it, and fell at a later date. Geology shows plainly that both have fallen; but their relative positions originally I argue from the botany alone.

Timbers.	Height in barometric feet.	Remarks.
Pin oak, black oak, pig hickory, *Liriodendron*, chestnut, and chestnut oak	1940	The mountain top here is level and broad, showing the slide of the rock cliffs that once capped it. So the timber here is not that which geologically belongs to the top of the mountain.

An irregular spur of the Black Mountain, almost at right-angles to the last section, gives, on its southern exposure, the following timbers:

Timbers.	Height in barometric feet.	Remarks.
Sweet gum, beech, red maple, shag hickory, black hickory, white oak (very massive), holly, *Liriodendron*, black locust, magnolia umbrella, black gum, white walnut, grey birch, black oak, and chestnut	base.	The character of the undergrowth here is somewhat different. It consists of azaleas, mountain oak, red oak, chestnut, dogwood, and some white oak, hickory, etc.
Liriodendron, white oak, shag hickory, water beech, black oak, red maple, black hickory, white maple, chestnut, june-berry . . .	100	It will be noticed that sweet gum, the magnolias, and holly disappear during the first hundred feet.
White oak, water beech, chestnut, witch hazel, *Liriodendron*, june-berry, black locust, black oak, pig hickory, rock maple, post oak, sourwood, dogwood, etc.	200	The shag bark hickory here disappears.
Mountain chestnut oak, black oak, white and rock maple, *Liriodendron*, white oak, pig hickory, dogwood, etc.	300	Here the undergrowth becomes very heavy, black oak and red oak predominating. Mountain chestnut oak makes its first appearance also.
Rhododendron maximum, mountain chestnut oak (in great quantities), pine (*mitis*), black hickory, American laurel, sourwood, etc.	330	A cliff of horizontal sandstone here changes the character of the timber almost completely.

TIMBERS.	Height in barometric feet.	REMARKS.
Dwarf chestnut oak, dwarf pine, dwarf and post oak, rock maple, sourwood, and American laurel	400	The sandstone cliff here still continues, but at a dip of 14°. It evidently belongs to the mountain top, but has slid down, for the rocks of Black Mountain are horizontal in their normal position.
White oak, chestnut oak, chestnut, black gum, and pin oak are the old growths	560	These timbers evidently belong to a position geologically below the 400-foot level.

In passing up the Cumberland from White Rock toward Mount Pleasant, the timbers are mostly white oak, beech, chestnut, red oak, Spanish oak, maple, etc., except where a ridge of the mountain juts down to the river, when pin oak, pines, mountain chestnut oak, black oak, etc., are introduced. Shag and white hickories are plenty along the bases of the mountains, pig and black hickories higher up. Hemlock abounds all along the little streams, to a height of fifty barometric feet above drainage.

After crossing over into Harlan county, I made a section to the top of Black Mountain, up Gray's branch, and came down a different way, so as to get two sections. The results are here given in detail:

TIMBERS.	Height in barometric feet.	REMARKS.
White oak, black oak, red oak, black gum, black walnut, maples, beeches, etc.	base.	The walnut timber here is only young growth, confined to open spots.
Beech, sugar maple, white maple, *Liriodendron*, red oak, linden, black gum, white oak, white hickory, shag hickory, grey birch, and blue ash	100	The mere list of trees here gives no idea of the splendor of the forest. The *Liriodendrons* are five to seven feet in diameter, with trunks sixty to eighty feet long. The white oak timber is also extremely heavy, and the blue ash as fine as any I ever saw.

Timbers.	Height in barometric feet.	Remarks.
Grey birch, beech, white maple, *Liriodendron*, blue ash, buckeye, red oak, black gum, spicewood, magnolia umbrella, etc. . . .	200	No perceptible change in the splendor of the forest.
Liriodendron, chestnut, shag hickory, red oak, beech, white oak, linden, maple, dogwood, etc. .	340	The linden is yet scattering, as it is found mostly in this part of Kentucky high up on the mountain side. The timbers are all heavy.
Liriodendron, chestnut, shag hickory, red bud, red maple, linden, june-berry, etc.	480	The *Liriodendron* remains as heavy as ever. The shag hickory is also very fine.
Growth same as above, with the addition of ironwood.	580	The linden first becomes very abundant at this height in ascending the mountain.
Liriodendron, chestnut, white ash, white hickory, red oak, linden, buckeye, ironwood, dogwood, etc..	700	Linden, chestnut, and *Liriodendron* are the chief timbers at this height.
Liriodendron, chestnut, white ash, blue ash, and most of the 700-feet timbers	850	At this height a sixteen-inch vein of coal crosses the hollow. The blue and the white ash are very fine indeed.
Black walnut, chestnut, *Liriodendron*, white hickory, linden, buckeye, etc.	1050	The splendor of the forest here can hardly be imagined. The belt of walnut before mentioned begins to show itself here, while the *Liriodendron*, chestnut, and white hickory are of the finest.
Black walnut, buckeye, *Liriodendron*, white ash, sugar maple, linden, white hickory, etc. . .	1250	At this height crosses the curious belt, 25 per cent. of whose timber is old forest walnut. In size and quality these trees have no superior in this country, so far as I know.
Chestnut, red oak, rock maple, black locust, pig hickory, etc.	1375	The walnut timber gives out below this height, and a ledge of rock here gives high mountain timbers. Linden gives out above this height.

380

TIMBERS.	Height in barometric feet.	REMARKS.
Red oak, buckeye, blue ash, white hickory, *Liriodendron*, chestnut, black birch, shag hickory, pin oak, etc.	1600	The ledge of rock above mentioned is crossed before reaching this height. The growth of white hickory so far above drainage is noticeable. It can be met with only on the richest ground at this height.
Chestnut (dwarf), pin oak, white oak (dwarf), black gum, American laurel, rock maple, sourwood, etc.	1790	Here the top of the mountain is reached, as the timbers indicate. The fact that there is so little change of timbers, where the differences of level are so great, shows that the underlying rocks are horizontal and hold the soil, so that it forms a rich loam from the bottom to the top of the mountain.

Notice here that this is not the height of the mountain above the river below, but only its height above the point at which I started up it, which was some three hundred feet above the river level.

In passing down the mountain by a different route, but few variations from the above tables were met with. The "sweet shrub" was one of these. The belt of walnut was found encircling the mountain at about the same height as given above.

The timbers on a spur of Black Mountain shooting off near the last section will suffice to give the differences between the timbers of the main range and one of its spurs:

TIMBERS.	Height in barometric feet.	REMARKS.
White oak, black oak, red maple, beech, buckeye, black hickory, black gum, linden, etc.	base.	The exposure here is south, and white oak is by far the predominant timber. It is not usual to see linden so low, and only one tree was found here.
Buckeye, black walnut, white oak, *Liriodendron*, chestnut, pig hickory, linden, and sugar maple .	120	White oak still predominates. A small amount of black walnut, not more than twenty inches in diameter. Only one linden tree.

Timbers.	Height in barometric feet.	Remarks.
White oak, blue ash, black oak, linden, chestnut, pig hickory, sourwood, chestnut oak, water birch, maple, etc.	250	White oak is here reduced in size and importance. Linden is more plenty, and the first chestnut oak appears.
Chestnut oak, june-berry, black hickory, sourwood, white maple, and black oak	300	Here white oak almost wholly disappears, as well as ash and linden.
Chestnut, chestnut oak, black oak, sourwood, dogwood, black gum, etc.	400	Here the timber is almost wholly chestnut oak, and evidently belongs higher up than that found upon the top of the bench given below.
White oak, white and pig hickory, black locust, black walnut, red maple, black oak, *Liriodendron*, etc.	500	The timber on top of this bench of the spur is fully equal to that at its base. I had not time to cross completely over the spur.

A section made on a spur of Pine Mountain, two miles below Mount Pleasant, gives the timbers mentioned below:

Timbers.	Height in barometric feet.	Remarks.
White oak, beech, black oak, *Liriodendron*, white sugar maple, red oak, sourwood, chestnut, black gum, grey birch, etc. .	100	The timber on Pine Mountain, at its most favorable points, is scrubby and ordinary. It is so even here at its base.
Chestnut oak, chestnut, black oak, *Liriodendron*, dogwood, black gum, sourwood, and grey birch	250	Here the mountain side is a perfect talus mass of fallen stones and débris. Timber more or less dwarf. White oak and beech have disappeared.
Rhododendron (maximum), chestnut (dwarf), sourwood, mountain oak (dwarf), etc.	350	Here there is a vast cliff of sandstone, dipping 22½° west southwest, from which the talus above was thrown. Timbers all dwarf. The cliff is about eighty feet high. *Liriodendron* disappeared at the cliff mentioned above.

Timbers.	Height in barometric feet.	Remarks.
Pine (*P. mitis*,) chestnut and chestnut oak (both dwarf), dogwood, sourwood, and American laurel	500	This is the top of the spur. Timber is all small—pine predominates.

I now give a section across Pine Mountain proper. It is triple-crested at this point (two miles below Mount Pleasant); that is, it is composed of three mountains, as it were, mashed in together, with their tops all distinct. The southern exposure is a very long and gentle slope, so that almost half a mile is sometimes gone over in a single hundred barometric feet.

Timbers.	Height in barometric feet.	Remarks.
White oak, black oak, chestnut, maple, *Liriodendron*, hickories, etc.	base.	Along the base of Pine Mountain here the timbers are very good—often, indeed, quite heavy.
Chestnut, chestnut oak, white oak (in small quantities), pin oak, black oak, pine (*P. mitis*), etc.	200	The chestnut here is very large, while the white oak is small and has almost disappeared.
Pine (*P. mitis*), chestnut, chestnut oak, black oak, and other timbers about as last	340	Very little change of timber from the level above, except that white oak has wholly disappeared on the first spur or crest of the mountain.
Mountain chestnut oak, scrub oak, American laurel, chestnut oak, chestnut, black oak, etc. . . .	430	Here there is quite a change in the timbers, chestnut and black oak growing scarce and other timbers coming in. Undergrowth very heavy—pin oak, hickory, black oak, pine, etc.
Mountain chestnut oak, American laurel, black gum, pine, chestnut, etc.	550	Here we reach the top of the first crest. The timber is almost wholly chestnut oak.
White oak, chestnut, black oak, and pine	520	This is a divide between two crests, is lower down barometrically than the last station, and gives very heavy white oak and chestnut timbers.

Timbers.	Height in barometric feet.	Remarks.
Chestnut oak, black gum, sour-wood, pine (*P. mitis,*) etc. . .	790	The timber here is again that of a high mountain side. The mountain slopes only 7° southeast.
Timber precisely the same as above.	1050	Another mountain crest. The slope of the mountain between these two points has been so gradual that no change in timber has taken place.
Chestnut, white oak, black locust, and chestnut oak	1030	This is a low divide between two crests again, and the chestnut and white oak are very heavy.
White oak, chestnut, grey birch, sugar maple, hickories, etc. . .	1185	This is the mountain top at this point; but in reality it is a gap in the mountain where the distance down to Beech Fork, on the north side, is only a few hundred feet.

The south exposure of Pine Mountain, as given above, is a gradual slope, whose steepness is just equal to the dip of its rock, and is about five miles long. On the north side, on the contrary, the rocks jut out, forming an almost precipitous descent to the waters of Beech Fork, at the base of the mountain. On the north side, where the rocks are not too precipitous, red oak, *Liriodendron* (very heavy), ash, and hickories are found. The total absence of *Liriodendron* on the south exposure, except right at the base of the mountain, and the total absence of white oak on the north exposure, deserve careful notice.

By merely glancing through the tables given above, it will be seen that, as a rule, subject of course to exceptions, near the base of a mountain such timbers as white oak, beeches, black ash, the magnolias, *Liriodendron* (yellow poplar), red oak, white and shag hickory, etc., are found. That none of these timbers, except the *Liriodendron*, reaches half way up the mountain, but are gradually replaced by chestnut, black oak, pin oak, pig and black hickory, linden, etc. That most

of these again give out on nearing the top of a mountain, and mountain oak, dwarf chestnuts, the pines (especially *P. mitis* and *rigida*, or yellow and pitch), etc., take their places. That the most marked change dependent upon exposure to different points of the compass is found in the case of the *Liriodendron* and white oak, the former flourishing most on northern exposures, the latter on southern. That the principal change noted in this part of Kentucky, due to geological formation, is furnished by the hemlock, which is found only on Conglomerate soils. These and other minor inferences can be deduced from a study of the tables.

The difference between the timbers of Eastern and Western Kentucky is not marked enough to be worthy of special notice beyond what has been given to it in previous pages. So it only remains to give a table of all the timbers met with in Bell and Harlan counties, which will be found below:

ORDER CUPULIFERÆ—MASTWORTS.

1. *Genus Quercus.*
   - White oak, Quercus alba (L.)
   - Post oak, Q. obtusiloba (Mx.)
   - Chestnut oak, Q. castanea (Muhl.)
   - Red oak, Q. rubra (L.)
   - Black oak, Q. tinctoria (Bart.)
   - Pin oak, Q. palustris (Mx.)
   - Scrub oak, Q. illicifolia (Willd.)
   - Dwarf chestnut oak, Q. prinoides (Willd.)
   - Spanish oak, Q. falcata (L.)
   - Swamp white oak, Q. bicolor (Willd.)
2. *Genus Castanea.*
   - Common chestnut, Castanea vesca (L.)
3. *Genus Fagus.*
   - Common beech, Fagus sylvatica (L.)
   - Red beech, F. ferruginea (Ait.)
4. *Genus Corylus.*
   - Hazelnut, Corylus Americana (Walt.)
5. *Genus Ostrya.*
   - Hop hornbeam, or ironwood, Ostrya virginica (Willd.)

ORDER JUGLANDACEÆ—WALNUT.

1. *Genus Juglans.*
   White walnut, Juglans cinerea (L.)
   Black walnut, J. nigra (L.)
2. *Genus Carya.*
   Pig hickory, Carya glabra (Torr.)
   Shag hickory, C. alba (Nutt.)
   White hickory, C. microcarpa (Nutt.)
   Black hickory, C. tomenlosa (Nutt.)

ORDER CONIFERÆ—CONIFERS.

1. *Genus Pinus.*
   Pitch pine, Pinus rigida (Miller).
   Yellow pine, P. mitis (Mx.)
2. *Genus Abies.*
   Hemlock, Abies canadensis (Mx.)

ORDER ACERACEÆ—MAPLES.

1. *Genus Acer.*
   Red maple, Acer rubrum (L.)
   Var. trident, A. rubrum tridens.
   White maple, A. dasycarpum (Ehrh.)
   Sugar maple, A. saccharinum (L.)
   Black sugar maple, A. nigrum (Mx.)

ORDER MAGNOLICEÆ.

1. *Genus Magnolia* (magnoliads).
   Cucumber tree, Magnolia acuminata (L.)
   Umbrella tree, M. umbrella (Lam.)
   Ear-shaped magnolia, M. fraseri (Walt.)
2. *Genus Liriodendron.*
   Tulip tree (yellow poplar), Liriodendron tulipfera (L.)

ORDER OLEACEÆ—OLIVEWORTS.

1. *Genus Fraxinus.*
   Black ash, Fraxinus sambucifolia (Lam.)
   White ash, F. Americana (L.)
   Blue ash, F. quadrangulata (Mx.)

ORDER BETULACEÆ—BIRCHWORTS.

1. *Genus Betula.*
   Black birch, Betula lenta (L.)
   Yellow Birch, B. excelsa (Ait.)
   Red birch, B. nigra (Ait.)

ORDER ERICACEÆ—HEATHWORTS.

1. *Genus Kalmia.*
   American laurel, Kalmia latifolia (L.)
2. *Genus Oxydendrum.*
   Sourwood, Oxydendrum arboreum (D. C.)
3. *Genus Rhododendron.*
   Rose bay, Rhododendron maximum (L.)
4. *Genus Azalea.*
   Azalea, A. viscosa (L.)
5. *Genus Clethra.*
   Sweet pepper, Clethra acuminata (Mx.)

ORDER TILIACEÆ—LINDENBLOOMS.

1. *Genus Tilia.*
   Basswood, Tilia Americana (L.)
   White basswood, T. hetrophylla alba (Vent.)

ORDER ANACARDIACEÆ—SUMACHS.

1. *Genus Rhus.*
   Black sumach, Rhus glabra (L.)
   Mountain sumach, R. copallina (L.)

ORDER ROSACEÆ—ROSEWORTS.

1. *Genus Cerasus.*
   Black cherry, Cerasus serotina (D. C.)
2. *Genus Amelanchier.*
   Wild service or june-berry, Amelanchier canadensis (Torr. and Gr.)

ORDER LEGUMINOSA—LEGUMINOUS PLANTS.

1. *Genus Robinia.*
   Black locust, Robinia pseudacacia (L.)
2. *Genus Cercis.*
   Redbud or Judas tree, Cercis canadensis (L.)

ORDER HAMAMELACEÆ—HAZELWORTS.

1. *Genus Liquidamber.*

Sweet gum, Liquidamber styraciflua (L.)

2. *Genus Hamamelis.*

Witch hazel, Hamamelis Virginiana (L.)

ORDER AQUIFOLIACEÆ—HOLLYWORTS.

1. *Genus Ilex.*

American holly, Ilex opaca (L.)

ORDER LAURACEÆ—LAURELS.

1. *Genus Benzoin.*

Spicewood, Benzoin odoriferum (Nees.)

ORDER CORNACEÆ—CORNELS.

1. *Genus Cornus.*

Dogwood, Cornus florida (L.)

Green dogwood, Cornus alternifolia (L.)

2. *Genus Nyssa.*

Black gum, Nyssa multiflora (Wang.)

Swamp black gum, Nyssa uniflora (Walt.)

ORDER ARTOCARPACEÆ—ARTOCARPS.

1. *Genus Morus.*

Mulberry, Morus rubra (L.)

ORDER PLATANACEÆ—SYCAMORES.

1. *Genus Platanus.*

Sycamore, Platanus occidentalis (L.)

ORDER SAPINDACEÆ—INDIAN SOAPWORTS.

1. *Genus Æsculus.*

Big buckeye, Æsculus flava (Ait.)

Small buckeye, A. pavia (L.)

ORDER ANONACEÆ—ANONADS.

1. *Genus Asimina.*

Papaw, Asimina triloba.

ORDER CAMELLIACEÆ.

1. *Genus Stuartia.*

Stuartia, S. Virginica (Cav.)

ORDER CALYCANTHACEÆ—CALYCANTHS.

1. *Genus Calycanthus.*

Sweet-scented shrub, Calycanthus floridus (L.)

GEOLOGICAL SURVEY OF KENTUCKY.

N. S. SHALER, DIRECTOR.

ON THE GEOLOGY

OF

HANCOCK COUNTY,

BY P. N. MOORE.

PART X. VOL. IV. SECOND SERIES.

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389 & 390

ON THE GEOLOGY OF HANCOCK COUNTY.

SURFACE FEATURES.

Hancock county is one of the smallest counties of Western Kentucky. It has an area of 168 square miles. Its northern boundary is the Ohio river, which, while flowing around this county, makes two large bends toward the north, so that the point where the county line comes to the river at the mouth of Blackford creek, on the western edge of the county, is further north than the point where the eastern line leaves it below Cloverport. Breckinridge county joins Hancock on the east, Ohio lies on the south, and Daviess on the west.

The principal stream of Hancock county is Blackford creek, which drains a larger part of its area than any other, and forms the county line on the west for a considerable distance. Yellow, Lead, and Indian creeks are other streams flowing into the Ohio river, which drain the northern part of the county, while the head branches of Panther creek drain the extreme southeastern corner, beyond the branches of Blackford creek.

This county does not present a great variety in its topographical features. The highest part of the county is in the extreme southeastern corner, at the head of Panther creek and Tar Fork, where the hills reach a height of more than 400 feet above the Ohio river. From here there is a gradual descent towards the west or northwest, until the hills of the main dividing ridges rarely rise higher than 200 feet above the river, while the general level of the country is much less.

Accompanying this decrease in height, toward the west, there is a change in the character of the hills. The slopes are not so steep, and there is a much larger proportion of level or gently rolling land. Toward the heads of the streams, in

the southeastern corner of the county, the hills are steep and the valleys narrow. The type of topography here seems to be produced by frequently alternating shales and sandstones, no one bed of which is of any great thickness or prominence. It is also partly due to the fact that, lying so near the heads of the streams, erosion has not been so great, as the amount of water in the streams is only that which has fallen upon it, and not the accumulation from above.

Near the Ohio river, in the upper part of the county, above Hawesville, the Conglomerate sandstone is present in considerable thickness, and gives rise to a topography, the principal features of which are comparatively even ridges, with gorge-like valleys and steep cliffs.

The Big Clifty or Tar Spring sandstone, at the base of the Chester Group, is also so heavy and coarse that it produces nearly the same result in the extreme eastern edge of the county, where the Conglomerate does not occur.

The heavy sandstones above the Conglomerate continue this type of topography, though with much less prominent features, and steadily growing less and less so, as far to the west as Hawesville, and for five or six miles back from the river. From here to the southern edge of the county these sandstones grow thinner and less prominent, and the hills lower, with more gentle slopes.

The topography of the western part of the county presents even less variety and fewer prominent features than the eastern portion. The hills are lower, and, especially toward the Ohio river, more gently sloping, and the valleys are wider. The streams, except at their heads, are sluggish, and have wide flat bottoms. In fact, the bottom lands of the Ohio river and the principal creeks form, probably, over one half the total area of the western part of Hancock county.

The prevailing rocks, as indicated by the topography and the exposures, which, however, are rare, are shales or shaly sandstones. On some of the higher ridges a coarse, friable sandstone occurs; but it is so soft and easily worn away that it has little more effect on the topography than if it were shale.

From the larger proportion of bottom land, and the more gentle slope of the hills, this part of Hancock county is much the best agricultural region. The wide and fertile bottoms of the Ohio river afford rich and valuable farms, while the hill land is all tillable, though not so valuable as the bottoms.

GEOLOGY.

The geological formations represented in Hancock county embrace only Carboniferous and Sub-carboniferous rocks, as follows:

Carboniferous,	- -	} Coal measures.
Sub-carboniferous,	-	} Chester Group. } St. Louis Group.

By far the greater portion of the county is embraced within the coal measures, which cover all of the western half of the county, and a large part of the eastern. The Sub-carboniferous rocks are found only in the eastern portion of the county; and as they are, both by area and comparative economic value, of less importance than the coal measures, they will be briefly treated.

The St. Louis Group is represented in this county in a very few places, and then only a very small thickness of the upper limestone is exposed. It is found only in the northeastern corner of the county, below the Big Clifty or Tar Spring sandstone. It is of no economic importance, and is hardly worthy of mention in this place, except as the lowest formation of the county.

THE CHESTER GROUP.

The Chester Group has been so often and fully described in the recent reports of the Geological Survey, that it is not necessary to repeat the description here. The character, thickness, etc., of the rocks of this group, and their area in this county, have been stated in the accompanying report on the "geology of the region adjacent to the eastern border of the western coal field," so that a brief statement is all that

is necessary here. The reader is referred to the above-mentioned report for more detailed information, should he desire it.

The whole thickness of the Chester Group, from the Big Clifty or Tar Spring sandstone, at the base, to the marly shales and marls at the top, is found in Hancock county, and both of the above-mentioned members are remarkably well developed. Chester rocks are found along the whole eastern border of the county, and extend from three to five miles to the west, inside the county, before they pass entirely beneath the drainage. In almost all this area the ridges, at least, are capped with coal measures; but there are a few isolated corners where the whole area is covered by Chester rocks.

One of these is near the Ohio river, at the northeastern corner of the county; but it is only of very small extent. Here occur the extensive marly shale deposits of the Buffalo Wallow, which have been described in the just mentioned report. These marly shales extend back from the river, along the eastern border of the county, nearly to its southern line; but they decrease in thickness in that direction. They are at their maximum near the river. These shales are also found further to the west near the river, and on Indian creek; but here, too, the thickness is comparatively small.

The Chester limestone is found along the river almost to Hawesville; but the last stream near the river in which it is seen is Indian creek. Back from the river, beyond the head of Indian creek, the Hawesville and Fordsville road may be roughly indicated as a boundary line, to the west of which the Chester rocks will not be found above drainage. This limit is given in more detail in the same report above referred to.

Occasionally, in the eastern portion of the county, a thin coal is found in the Chester rocks. It shows near the river above Indian creek, and is reported at low water in the bank of the Ohio river, above Hawesville. It is of no economic value, as it is never workable; but, in spite of this fact, time and labor are occasionally spent by parties in digging into this

coal, in the vain hope that it will prove thicker when followed underground some distance—a hope which, it is needless to say, is never realized.

COAL MEASURES.

The boundary of the coal measures of this county has been already given in the accompanying report, which has been so frequently referred to, and it is shown in the accompanying map by Mr. Page.

Coal-measure rocks are found over nearly the whole of the county, although in the eastern portion they cap only the tops of the hills, the larger part of the area being Chester rocks. From the just indicated line of the disappearance of the Chester rocks, westward to the limits of the county, nothing but coal-measure rocks are found.

We find in Hancock county a maximum thickness of about 475 feet of coal measures, from the base in the eastern part of the county to the highest rocks on the Blackford Creek hills in the western. The greatest thickness measured in any one section is about 200 feet, so that the following general section is obtained by the combination of three typical sections from the eastern, middle, and western portions of the county. Like all general sections, it serves only as an outline or key to the stratification of the county, and is subject to much variation locally. Moreover, in this county the changes in the rocks, which occupy the same geological horizon, are very great, expecially the change from coarse sandstone to shale, and *vice versa;* hence the necessity of the indefinite statement "shale and sandstone," which is used occasionally in the general section. For more detailed illustrations of the character and changes in the rock strata of this county, the reader is referred to the accompanying plates of sections which are drawn from actual measurements at the points named. These sections, with others not published, are the material from which the general section is constructed; but they are more accurate than it is possible to make a general section, which must be averaged from them all:

GENERAL SECTION FOR HANCOCK COUNTY.

24.	Sandstone and shale	20 to 30 feet.	
23.	Coal (?) reported in well	1 "	6 inches.
22.	Coarse, friable sandstone	20 to 30 "	
21.	Shale	15 to 20 "	
20.	Coal, Lewsport coal	3 to 4 "	
19.	Shale and sandstone	40 to 45 "	
18.	Coal	1 "	
17.	Shale and shaly sandstone	15 to 25 "	
16.	Limestone	2 to 12 "	
15.	Coal, Adams', Lawson's, Bruner's, &c.	2 to 4 "	
14.	Shale and shaly sandstone	40 to 50 "	
13.	Coal, Jas. Mason's	2 "	
12.	Shale and sandstone	70 to 88 "	
11.	Coal		4 to 10 "
10.	Coarse sandstone locally changing to shale	50 to 80 "	
9.	Coal, Main Hawesville	2 to 4 "	
8.	Shale and sandstone	40 to 50 "	
7.	Coal?		4 "
6.	Shale	25 to 30 "	
5.	Coarse sandstone; upper member of Conglomerate?	20 to 30 "	
4.	Shale	20 to 30 "	
3.	Coal		7 "
2.	Shale	4 to 8 "	
1.	Conglomerate sandstone	35 to 60 "	
	Top of Chester limestone.		

The above section holds good for all of the northern and western portions of the county, and as far south, at the centre of the county, as Sulphur Fork of Blackford creek. The southern and southeastern portions, however, present a very different section, and one that is not so well known as yet. Here the section embraces not more than 150 feet of coal measures, which include two or three thin coals. The rocks are not well exposed, but seem to be thin-bedded sandstones and shales. Exposures and developments are so rare that sufficient time has not been devoted to this region to construct a general section which will be of value. The general section given in the accompanying report for the region adjacent to the eastern border of the coal field is more applicable to the southeastern part of Hancock county than the one just given.

The Conglomerate sandstone is not known in this part of the county, or, if represented at all, it is by a coarse, friable sandstone, which is sometimes found below the lowest coal. Going toward the north, the Conglomerate is first found on Caney and Lead creeks, and near the Ohio river it forms a prominent member of the rock series. It will be referred to further along.

In the plates of sections accompanying this report is reproduced the general section by Dr. D. D. Owen for Hancock county, published in volume I, first series Kentucky Geological Reports. The section as originally published embraced also the Sub-carboniferous rocks of Hancock and Breckinridge counties; but that portion of it is not republished, as it is not of especial interest in the present discussion. Dr. Owen, at the time of the publication of his section, had evidently not examined the western part of Hancock county, as he does not include the highest rocks of the county by about 150 feet—his section extending no higher than the rocks immediately below Hawesville, in the hill above the old Hawes shaft.

A comparison of Dr. Owen's section with the sections in the accompanying plates, and the general section just given, will show considerable differences. The upper part of the section corresponds very closely with the sections obtained by the writer, both in thickness and character of rocks, with the single exception that Dr. Owen records a coal eight inches thick, the second coal above the main Hawesville seam, of which the writer has seen no satisfactory evidence.

The lower portion of the section, from the Main Hawesville coal to the base, is, according to Dr. Owen, about fifty feet thicker than any measurements by the writer; and it also shows one more coal than has been seen by him. Dr. Owen, in his report, states that the evidence upon which he placed this coal in his section was obtained from borings made near Cannelton, Indiana, on the opposite side of the river from Hawesville. There was probably some mistake made in the records of the borings, or, if this coal be present on the Indiana side, it is not on this, for the rocks have been seen at too many exposures to leave any doubt in the matter. It is but due to Dr. Owen also to state, that, in publishing this section, he expressly states that it is only preliminary, and subject to correction.

In volume III, first series Kentucky Geological Reports, page 458, Mr. S. S. Lyon publishes the following addition to

Dr. Owen's section for Hancock county, beginning with the upper coal of that section, and including the higher measures of the western part of the county:

Soft yellow sandstone	20 feet.		
Sandy shale	8 "		
Marly shale, with segregations of limestone	3 "		
Black bituminous shale	4 "		
Lewisport coal	4 "	4 inches.	
Covered space	36 "		
Sandy shale	6 "		
Sandstone	2 "		
Coal	1 "		
Covered space	14 "		
Limestone	9 "		
Thin sandstone and sandy shale	16 "		
Calcareous chert beds	7 "		
Marly, sandy, indurated mud	1 "	7 "	
Very hard, black, pyritiferous limestone		7 "	
Coal. Top of Dr. Owen's section	1 "	6 "	

The coal at the base of this section is the coal at the top of the hill above the old Hawes shaft, near Hawesville, the coal mined by Mr. Adams on Lead creek, and the coal found to the southwest, in the vicinity of Utility, and on Caney and Blackford creeks.

This section of Mr. Lyon corresponds very closely with those obtained by the writer in his examinations in this county, some of which are given in the accompanying plates; but there is probably a mistake in the number and thickness of the limestones which are shown at the bottom of the above section. There should be but one limestone here, the same which is shown at the top of Dr. Owen's section. This limestone is from two to ten feet thick, and is usually overlaid by shale or shaly sandstone. There is nowhere in this county, within the observation of the writer, any such thickness of cherty rock, or any second limestone overlying this, as represented by Mr. Lyon.

The limestone above referred to is one of the most persistent strata in the whole county. It has been traced all through the western part of the county, from Hawesville, where it disappears, going up the river to Blackford creek. Through all this region it retains its identity remarkably well, and, in consequence, serves as a valuable geological datum.

Mr. Lyon has shown the proper number and position of the coals in the above section.

The general section of Hancock county shows, therefore, a total of nine different coal seams; four of which, namely, the Main Hawesville, the Mason, the Adams or Hawes Hill, and the Lewisport coals, are well-known persistent seams, and are or have been worked. The other seams, especially the two below the Main Hawesville coal, are thin, of no economic importance, and so little has been seen of them that it is impossible to say whether they are persistent or not, and really deserve a place in the general section.

The equivalency of these seams with those in other parts of Western Kentucky is not entirely determined. The section seems not to exactly resemble any other, heretofore published, for the western coal field. In fact, the changes in this county toward the southeast corner are such as to render identification of seams across even that short distance difficult or impossible. The character of the section in the northern and western parts of the county is such that the coal seams can be much more easily traced and identified. There is a large unexamined area around this county to the south and west, between it and other parts of Western Kentucky, where the coal seams have been identified and numbered; but until this area has been carefully surveyed, and the coals traced across it and connected with those of Hancock county, no certain equivalency can be asserted. It is probable that when this is done some of the coals will be found occupying the positions of certain of the more persistent and trustworthy seams of the western coal field, and that others will be found to be local. In the meantime, the equivalencies which seem the most probable may be stated, but it will be subject to revision.

In the report of the Geological Survey of Indiana for 1872, page 98, Mr. E. T. Cox, the State Geologist of Indiana, while discussing the geology of Perry county, Indiana, which lies across the Ohio river from Hancock county, Kentucky, gives a section at the Hawes mine, including the hill above. This section extends from the Main Hawesville to the Adams

coal, the upper coal of Dr. Owen's general section for this county. Mr. Cox's section is as follows:

Slope.			
Sandstone "Anvil Rock?"			
Sandy shale.			
Limestone	6 feet.		
Coal K, with 12 inches of clay parting	2	"	6 inches.
Sandstone and shale	60	"	
Coal I.			
Sandstone and shale	80	"	
Coal H	1	"	6 "
Sandstone	30	"	
Coal G	1	"	
Hard, bluish shale	25	"	
Black bituminous shale	15	"	
Coal F, "Hawes Coal"	4	"	

The above section is copied exactly as published by Mr. Cox. He has used his Indiana nomenclature for the different seams, for the purpose of comparison with his sections for Perry county, Indiana. The measurements of this section agree fairly well with those obtained at the same place by the writer, except that the total distance from the main Hawesville coal to the coal at the top of the section is some ten feet greater. Mr. Cox, however, records a coal G, which the writer of this has no certain evidence of. It is probable that Mr. Cox has placed it in the section, from the report of its having been found in the Hawes shaft. It is stated that there was such a coal passed through in sinking the shaft, but it is also denied on equally good authority; and as there is little evidence of it at any other point, it has not been deemed best by the writer to give it a place in the section.

In volume III, 1st series Kentucky Geological Reports, page 563, Mr. Cox, who was then an Assistant of the Kentucky Geological Survey, identifies the coal at the top of this section as No. 11 of the Kentucky general section. This identification is apparently from palæontological evidence only. In the Report of the Indiana Geological Survey, above referred to, he repeats his belief in this identification, and refers to the surprise of himself and Prof. Lesquereux "on finding at Hawes' mine, near Hawesville, the whole of the coal-measure strata, from the 'Anvil Rock' sandstone to the Conglomerate sandstone."

That Prof. Lesquereux did not agree with Mr. Cox in this identification as No. 11, is evident from the fact, that, in his report, volume III, 1st series Kentucky Geological Reports, page 535, he refers to this coal as No. 3. That Mr. Cox is mistaken is readily ascertained by a short examination of the stratigraphy of the western part of Hancock county. The character of the rocks here is shown by the general section and the sections of the accompanying plates. It is shown in these sections that there is a thickness of about 125 feet of strata, including two, and perhaps three seams of coal, one of which is of workable thickness, and is one of the most trustworthy coals in the county, above the coal which Mr. Cox identified as No. 11, and the sandstone which he calls the "Anvil Rock." Of this fact there is the most complete stratigraphical evidence, for the rocks which identify and connect the sections can be traced without difficulty from the Hawes hill to the western part of the county, where they pass under the sections which show the Lewisport coal. This coal is the second seam above the coal at the top of Mr. Cox's section. The distance between is from 60 to 70 feet.

Prof. Lesquereux, in volume III, first series Kentucky Geological Reports, page 544, identifies the Lewisport coal as No. 9. This identification, like that of Mr. Cox, seems to be based entirely upon palæontological evidence. Prof. Lesquereux has, therefore, identified one coal as No. 9, while another, which is known, from the best stratigraphical evidence, to be only 70 feet below, he has called No. 3. Mr. Cox has called the same coal No. 11.

According to Dr. Owen's general section for the western coal field, the normal distance from coal No. 9 to coal No. 3 is about 500 feet. The distances, according to Dr. Owen's section, are undoubtedly somewhat too great, as shown by Mr. Norwood's more recent sections in the central and southern part of the field; but no such great decrease in the thickness is known as would be indicated by the above identification.

These discrepancies and mistakes afford a striking instance of the incompetency of palæontological evidence alone, even

when in the ablest hands, for the identification of coal seams over any great distances. Palæontological evidence is undoubtedly of great value, when used in connection with and as corroborative of stratigraphical evidence, but alone, it is insufficient to give a trustworthy basis for conclusions.

The identification by Prof. Lesquereux of the Lewisport coal as No. 9 is possibly correct, although it is by no means certainly determined, as it yet lacks the stratigraphical evidence necessary to settle its equivalency beyond a doubt; but the position of the coal, its persistence and uniformity of thickness, as well as the evidence from its palæontology, which convinced Prof. Lesquereux, all tend to prove that it is the No. 9 coal, or coal D, using Mr. Norwood's temporary nomenclature for the coal seams of Western Kentucky. If this be the case, it shows a thinning of the section of the western coal field, much beyond even that indicated by Mr. Norwood's sections, in the region adjacent to the Louisville, Paducah and Southwestern Railroad.

The coals of the lower part of the section for Hancock county have not yet, and cannot, in the present state of our knowledge, be positively identified and numbered with the seams of the general section for the western coal field. It has been deemed best, therefore, to give them only the local names, which will serve to identify them throughout the county, and to leave the final numbering until the connection has been traced across the interval which now separates them from parts of the coal field where the identity and equivalency of the coals have been well established.

The number of coals in the general section for the western coal field, and the final nomenclature to be adopted, have not as yet been determined, and it is therefore best, before forcing a classification in any one section, to wait until the field has been more widely studied, and it can be found which coals are persistent and thick over the whole field, and which are only local.

DESCRIPTIVE GEOLOGY.

The geology of the southeastern part of this county has been outlined in the discussion of the topography; and it has been stated that it differs in the character of its prevailing rocks from that part nearer the river. The Conglomerate sandstone is here missing, and there is a greater prevalence of shales and thin sandstones. With one very valuable exception, the coals seem to be thin. It is but justice to say, however, that exposures are rare, and that thorough prospecting does not seem to have been done over much of the region; but where seen, the coals were mostly thin, and they are reported thin at other places where not seen.

The exception above referred to is the celebrated Breckinridge cannel coal, the mines of which lie in the edge of Hancock county, on one of the head branches of Tar Fork. This coal has been made the subject of a special report by Mr. Norwood, in which its value is discussed at length. To this report the reader is referred for detailed information. It is necessary here to repeat only a few facts in regard to its position, etc., in its relation to the general section of the county.

It is a cannel coal of excellent quality, from 24 to 33 inches thick, occurring from 25 to 30 feet above the Chester limestone, with a coarse, micaceous, soft sandstone between. The hills in the vicinity of the mines rise about 100 feet above the coal. There are but few exposures of the rocks above the coal, and a full section has not been obtained. The following section, obtained at a shaft recently sunk in this vicinity, shows a portion of the rocks in the ridge above the coal in more detail than anything heretofore published. The records of the shaft were obtained from Mr. M. R. Taylor, of Cloverport, by whom it was sunk. At the time of visit, the shaft was full of water. The bottom of this shaft is probably 10 or 15 feet above the coal. The exact level was not determined. The location of the shaft is not more than one half mile distant from the entries in the valley:

SECTION.

Soil	9 feet.	
Grey shale	10 "	
Shaly coal		2 inches.
Light shale	10 "	
Band of iron ore		1½ "
Dark bituminous shale	8 "	
Coal		3 "
Very black shale	18 "	
Sandy shale	3 "	
Total	58 "	6½ "

This coal, like all cannel coals, seems to lie in a basin of limited extent, and at a distance of a few miles on all sides it is no longer found. The present mines are in the dividing ridge between a branch of Tar Fork and Panther creek. The drifts are all on the Tar Fork side. On the Panther creek side of the ridge it is reported that the coal has been found at a number of localities; but it was long since the explorations were made, and the openings have all fallen in, so that nothing can now be seen of the coal at any of them.

To the west of this the coal has not been seen by the writer, and very little has been heard in regard to it. At the time of the development of the property extensive explorations were made by the company operating the mines; but nothing has been learned as to the results which they attained. It is probable, however, that the results were negative, or the facts would be known. To the southwest, on Adams' Fork, in Ohio county, is an exposure of cannel coal or cannel shale, which probably occupies the position of this coal. It has been described in the accompanying report on the "Geology of the Region Adjacent to the Eastern Border of the Western Coal Field."

The equivalency of the Breckinridge cannel coal has long been a matter of discussion. It is undoubtedly the lowest workable coal of the section, and, as such, the equivalent of coal No. 1B of the old reports, or coal L, using Mr. Norwood's temporary nomenclature; but, in the opinion of the writer, it occupies an independent basin, and cannot be traced to an absolute identity with any other seam, although it may occupy nearly the same position.

On Panther creek few coals have been seen; but those reported are mostly thin, and have never been worked to any extent, though often opened for exploration.

The Chester limestone disappears below the drainage on Panther creek, near Mr. S. G. Lane's. From here to the western border of the county, in the vicinity of Pellville, the dip of the rocks is slight, not over 20 to 30 feet to the mile. The total thickness of rock above the base of the coal measures is not more than from 200 to 250 feet. The principal features of the topography have been before described. Toward the west the hills decrease in height, and slope more gently, while the prevailing rock is shale. There is a considerable area in the southwestern portion of this county and the adjoining region, in Ohio county, where these characteristics prevail, and where there is an unusual thinning of the coals. The coal best known seems to be the equivalent of the Fordsville coal, described in the accompanying report. It is, however, usually thin, rarely measuring as much as 24 inches in thickness, and more commonly 18. The only workable coal known in this region is at Mr. R. S. Lanum's, in Ohio county, about one and a half miles southwest of Roseville. The coal here at the mouth of the entry, and for some distance back, is only about 20 inches thick; but it gradually increases in thickness, until at end of the drift, about 100 yards in, it measures 40 inches, including 3 inches of slaty coal at the bottom. The equivalency of this coal was not satisfactorily determined, but it is probably coal H. It lies here very near the drainage level, and probably passes below to the west. The following is an analysis by Dr. Peter and Mr. Talbutt of a sample of coal from this bank:

Moisture	6.00	
Volatile combustible matter	37.80	
Fixed carbon	48.70	Coke 56.20
Ash	7.50	
Total	100.00	
Sulphur	3.180	
Specific gravity	1.292	

Going toward the Ohio river, coarse, hard sandstones occur in increasing frequency and thickness, and, in consequence, outcrops are more numerous, and it becomes easier to trace the strata across the country, and to determine the geological horizon at any point.

The most prominent of these sandstones is the Conglomerate. This here, as almost everywhere else in Western Kentucky, is very irregular in its occurrence and thickness. It is first seen going toward the north, near the heads of Caney and Lead creeks. To the west it disappears below the drainage on Caney creek, a short distance above the crossing of the Hawesville and Pellville road; on Lead creek at the same road crossing, and on the Ohio river at the branch which runs through the upper part of the town of Hawesville. Its further continuation to the westward is here cut off by a fault, and a fold or bend in the strata, which bring the rocks on one side of the ravine about 90 feet lower than they are on the other. The absolute fault or slide in the rocks is probably not more than 20 or 25 feet; but there is a very steep dip close to the line of this fault, which brings the rocks down the remainder of this distance before it is modified. This is proved by the fact that the coal has been worked up to the fault line at several places, so that the dip can be very closely followed.

The Conglomerate here consists of two members, only one of which, however, the lower, is commonly known as the Conglomerate. This is here from 35 to 45 feet thick. Above it, separated by from 15 to 30 feet of shale, is another coarse sandstone, from 20 to 35 feet thick, which is also, at places, conglomeratic, being largely composed of small and rather angular quartz pebbles. These pebbles are more abundant further up the river, toward Indian creek, than near Hawesville. There is a thin coal in the shale between these two sandstones, from five to eight feet above the top of the lower. It has occasionally been dug into, in the hope of finding it thick enough for profitable working; but the greatest thickness reported is seven inches.

The presence of two Conglomerates, with a coal between, is not an unusual occurrence in the western coal field. They occur in Edmonson county, and are shown in the sections of part II, volume II, second series Kentucky Geological Reports. They are also noted on the western border of the field, in Livingston county, by Mr. Norwood, in his report, part VII, volume I, second series.

Both of these sandstones, near Hawesville, furnish excellent building stone. They have both been largely quarried, but the upper one most extensively. From the quarries here a large part of the rock for the locks on Green river, for the Government building at Memphis, and other extensive public works, was obtained. A sample of the stone from this quarry received an award at the Centennial Exhibition in Philadelphia in 1876.

About three miles from Hawesville the two sandstones can no longer be distinguished as independent beds, but instead, we have a massive Conglomerate, very conspicuous and frequent in outcrop, about 75 feet in thickness, which seems to represent them both. The change by which this is effected is obscure and has not been traced in as great detail as could be desired; but it is the only hypothesis which satisfactorily explains certain apparent great changes in the position of the coals above.

About 60 feet above the lower Conglomerate, and 20 feet above the upper or quarry sandstone, in the river hills above Hawesville, a thin coal is reported to have been found at several places. It is stated as only four inches thick, and therefore of no economic importance. It has not been seen by the writer except in very indistinct outcrop; but the authority upon which it is reported is so good, that there is little hesitation in placing it in the section. It is shown in plate I of the accompanying sections. This coal, and the other thin coal lying close to the top of the lower Conglomerate, occur on the opposite side of the river in Indiana, and are shown in the sections of Mr. Cox's report on the geology of Perry county. These sections of Mr. Cox uniformly show

greater distances between coals than have been obtained by the most careful measurements on the Kentucky side of the river; but otherwise they generally bear a close resemblance in the character and order of the different strata.

There is but a very small area in Hancock county where these two coals are known, as they pass below the drainage to the west about the same time the Conglomerate does, and to the east the lower one disappears with the change in the Conglomerate just referred to, while the upper of the two, even if it extend as far as the underlying Conglomerate, has but a very limited range. It is only known in the immediate vicinity of Hawesville.

THE MAIN HAWESVILLE COAL.

At 110 feet above the lower or main Conglomerate, occurs the coal which is best known, has been most worked, and is of most value in Hancock county. It is generally known as the Main Hawesville coal, a name which was used in the 1st series Kentucky Geological Reports, and which will be retained here. It is the same coal as the Cannelton coal of Perry county, Indiana.

The coal varies greatly in thickness, occurring over considerable areas, ridges, as it were, in the coal seam, where it is hardly more than a streak, and then covering other areas, where it is from 3 to 4 feet thick. In the mines where it is worked, it varies from 2 to 4 feet, with an average of perhaps a little more than 3. Below the coal, between it and the fire-clay, is commonly found a very hard bituminous slate, which ranges from 4 inches upward, becoming thicker as the coal thins, until it often forms the main body of the seam. The upper part of the seam is usually of a semi-cannel coal, but this is only a few inches. The main portion is a rather dry bituminous coal, of very good quality.

The distance between this coal and the main Conglomerate is not as great as stated in the reports of Dr. Owen, nor as reported in Perry county, Indiana, by Mr. Cox, who places the distance at 148 feet, in Cannelton. It has been measured

carefully with aneroid barometer, hand level, and finally with spirit level and rod; and in no case has it, near Hawesville, been found more than 115 feet. This coal, above Hawesville, at the old mines, is about 150 feet above high water in the Ohio river. From here it dips to the west, until, just above Hawesville, it is about 100 feet above. The fault and bend in the rocks before referred to, at the upper edge of Hawesville, bring the coal down to 10 or 15 feet above, and at the lower edge of town it is near the level of high water or a little below. Here another fold occurs, which increases the dip, until, less than a mile below, the coal was found in the old Hawes shaft, before referred to, 70 feet below high water in the Ohio. These disturbances in the rocks do not seem to extend to the south beyond Lead creek. The coal has been worked through the hill from Hawesville to Lead creek, west of the fault line. There is probably a cross-fault running down the valley of Lead creek; for, on the north of the creek, where this coal has been worked, it is about 25 feet above the creek, while on the hill south, in the old Pellville road, the same coal is 135 feet above. This fault does not seem to extend more than one half mile above the Pellville road crossing, as above this the coal occupies very nearly the same level on both sides of the creek.

At the Hancock mines, in the ridge between the waters of Indian and Lead creeks, a little more than three miles southeast of Hawesville, this coal is only from 50 to 55 feet above the top of the Conglomerate, which is here at its maximum thickness. The different members cannot be distinguished here, and it is probable that the upper and the lower are united. The space between the top of the Conglomerate and the main coal is covered, so that nothing could be learned as to the presence of the thin coal next below it. The decrease in the distance between the main coal and the Conglomerate, at this place, is marked. It is even less than the usual distance from the top of the second Conglomerate or quarry sandstone to the coal, and about half the distance from the lower Conglomerate. This decrease occurs in less

than two miles distance from some of the old drifts above Hawesville, where the coal is at its normal height above the Conglomerate.

If this decrease in the distance between the coal and Conglomerate toward the southeast be continued beyond the head of Lead creek, it strengthens the hypothesis of the equivalency of the Main Hawesville and the Breckinridge cannel coals, both of which were classed as No. 1B by Prof. Lesquereux, in volume III, first series Kentucky Geological Reports. The stratigraphical evidence has, heretofore, seemed strongly against any such equivalency; but the disappearance of one of the thin coals below the Main Hawesville seam, and the probable disappearance of the other, the persistence of the main seam, and the lessening of the distance between it and the Conglomerate, all tend to encourage the hypothesis that further to the southeast this coal may be the lowest coal of the basin, as it is here undoubtedly the lowest workable seam. This, however, has not as yet been proved, and cannot be until the coal has been carefully traced across the intervening space between the Hancock and the Breckinridge mines—a matter of much difficulty as yet, as hardly any openings have been made, and natural outcrops are extremely rare.

The Hancock mines are the most extensively worked, at present, of any in this county. They are owned by the American Cannel Coal Company, of Cannelton, Indiana. The coal is shipped to the river by a railroad about two and one half miles in length, the grade of which is sufficient to allow the cars to run of their own weight to the river, from which they are hauled back by mule power.

The main coal has been mined in the vicinity of Hawesville for more than thirty years past. The old Reverdy and Trabue mines were among the first and largest on the lower Ohio. At present, however, nearly all of the available coal in the river hills near Hawesville, between the river and Lead creek, has been exhausted, and no mining is now carried on here, save in a desultory manner for local supply, in corners and patches, which were left unexhausted when the large mines

were abandoned. All of these mines were worked by drifts. At the old Hawes mine, below Hawesville, the coal was reached by a shaft variously reported from 60 to 80 feet deep. The mine, however, running under the Ohio river bottoms, was a very wet one, and finally had to be abandoned on account of the great influx of water, although the coal available from the shaft was not exhausted.

In the vicinity of Hawesville, the coal is reported to have been very irregular in thickness, frequently occurring over considerable areas entirely too thin to be worked. These areas probably occur at the summits or ridges of waves in the coal seam. In the country back of Hawesville there is yet a large area of this coal of workable thickness, good quality, and wholly undeveloped. In fact, it has hardly been fairly prospected; but enough is known to justify the assertion that there is here a vast amount of cheaply available coal. It is to this region that the people of Hawesville and the central part of Hancock county must look for a renewal of their former mining prosperity. The supply of coal is ample, both in thickness and area, for many years of continued and extensive mining operations.

In the ridge between Lead and Caney creeks, south of Hawesville, this coal has been opened at a number of places, but at only one of these, near the Hartford road, was it seen. This is called the Breckinridge bank. The coal is here 44 inches thick, but this includes 6 inches of bituminous slate at the bottom; so that the clear coal measures only 38 inches. Near the old Pellville road, the coal has been opened in two places; but they have now fallen in, so that nothing could be seen of the thickness. It is reported to be 3 feet thick; but this is denied by others, and the statement is made that it was found too thin to work. The fact that the drifts were abandoned without mining any amount of coal tends to confirm this statement. The coal dips rapidly to the west from the old Pellville road, where, as already stated, it is 135 feet above Lead creek, until it is only found above the drainage level a short distance west of the new Pellville road. This rapid dip

is probably produced by the continuation to the southward of one of the folds which were noted at Hawesville. The same coal is now being worked in a small way on the waters of Lead creek, between the creek and the river, some distance above the Hartford road. Here, at the time of visit, the coal measured 34 inches, and the under slate 14. Little is known of the coal on the south branches of Lead creek, above here, until at the head of the creek, in the ridge between it, Caney creek, and Sulphur fork of Blackford, where a bank was formerly opened, and the coal hauled to Cloverport. It is reported to be nearly 4 feet thick at this place, but access could not be had to it to measure it, as the drift had partially fallen in. From what could be seen, however, it seems likely that the thickness is not very greatly overestimated.

On Caney creek, and in the ridge between that stream and Blackford creek, this coal is well developed, and has been opened at a number of localities sufficiently well to show its character and thickness. The nearest opening to the one just described is at Mr. J. Richey's. Here the coal is so near the level of the creek that the drifts had filled with water at time of visit, and the coal could not be measured; but it is reported to be three feet thick.

About one mile west, at the Jesse Rice bank, the coal has been opened, and shows a thickness of forty-seven inches, including three inches of bottom slate.

Still further down the creek Mr. Jacob Royall has a drift in this coal, where it is forty-two inches thick. This drift is near the Pellville road.

There is a marked undulation in the rocks along Caney creek between the crossings of the Fordsville and the Pellville roads. At Mr. Richey's, in the Fordsville road, the coal is near the level of the creek. At the Jesse Rice bank it is 30 to 40 feet above. Between the Hartford and the Pellville roads, at Mr. T. Burkis', the Conglomerate rises to 20 or 30 feet above the creek level, descending rapidly again to the west, and passing below the creek before the Pellville road is

reached. The coal at the Royall bank is about 60 feet above Caney creek.

This reversal of dip may be due to some as yet undiscovered fault or faults, the continuation to the southward of the more marked disturbances at the river; but the region has not yet been studied in sufficient detail to justify the positive assertion that this is the case.

On the Blackford creek side of the ridge the coal has only been seen well exposed at one locality—Mr. John C. Schafer's bank. It is on a small branch running into Blackford creek below the Pellville road crossing, and about one mile distant from the creek. It is about 50 feet above the creek. The coal here is of excellent quality, being freer from sulphur than at any other place from which a sample has been analyzed. It is 43 inches thick, including about one and one half inches of shale parting.

The same coal was formerly opened on the old Taylor place, near the Blackford Meeting-house, on the Pellville road. It is reported to be about the same thickness as at the Schafer bank. South of Blackford creek the coal was formerly opened at Mr. Glover's, on the Pellville road; but it cannot be seen now. It is reported 30 inches thick. At Mr. Baker's, where it is next seen beyond Mr. Glover's, it is only 18 inches thick. Beyond Mr. Baker's to the south, the coal has not been positively identified. To the westward it passes below the drainage between the Pellville and Knottsville roads, and a higher coal becomes the best known seam.

QUALITY OF THE MAIN HAWESVILLE COAL.

The following analyses, by Dr. Peter and Mr. Talbutt, Chemists of the Survey, from samples selected by the writer, serve to show the chemical composition of the coal from this seam. The samples were intended to be as nearly representative of the whole thickness of the coal as possible:

	1	2	3	4	5
Moisture	5.12	3.30	5.20	5.10	7.46
Volatile combustible matter	36.28	39.00	38.70	41.20	33.14
Fixed carbon	47.60	50.50	48.50	46.60	55.20
Ash	11.00	7.20	7.60	7.10	4.20
Total	100.00	100.00	100.00	100.00	100.00
Coke	58.60	57.70	56.10	53.70	59.40
Sulphur	4.038	3.373	2.266	3.331	1.368
Specific gravity	1.357	1.268	1.336	1.292	1.308

No. 1 is from the Hancock mines.

No. 2 is from the Davidson bank, near Lead creek, above Hawesville.

No. 3 is from the Bergenroth bank, Lead creek.

No. 4 is from the Bridenbach bank, south of Lead creek.

No. 5 is from the Schafer bank, near Blackford creek.

It is probable that, in selecting the sample No. 1 from the Hancock mine, too much coal was taken from the lower part of the seam, where it is becoming slaty; hence the per centage of ash is probably shown larger than the proper average of the whole seam.

The character of the rocks above the Hawesville coal is subject to great variation. Shales and coarse sandstones alternately overlie the coal, and change from one to the other frequently. Near the Hancock mines, it is reported that in one of the exploration shafts sunk when the property was in process of development, a thickness of 50 feet of shale was passed through before reaching the coal. Above this shale, however, a coarse sandstone from 20 to 25 feet thick occurs.

Nearer Hawesville, at the old Reverdy mines, a coarse sandstone occurs from 15 to 20 feet above the coal; the space between is probably filled with shale, but it is covered so that it was not seen.

At the upper part of the town of Hawesville there is a thickness of about 50 feet of shale above the main coal, between it and the massive sandstone which caps the hill here.

Near the top of this shale a thin coal is reported, but has only been seen here by the writer as a "stain."

It is probable that this is the first coal given in the general section above the main coal. Below the fault at this place the sandstone comes rapidly down to the coal, until at the old drifts, in the lower part of town, it is almost immediately above, separated by only from 5 to 7 feet of shale. A second sandstone appears here about 30 feet above the first, and the coal next above the Main Hawesville lies between them, about 60 feet above it. This coal was once opened here, it is reported, and found to be about one foot thick. The character of the rocks here is shown by a section in plate I. South of Lead creek, as far as Blackford creek, the coal is closely overlaid by a coarse sandstone about 30 feet thick. Beyond Blackford creek this sandstone disappears.

The fold in the rocks, at the lower edge of the town of Hawesville, brings the coal next above the main seam down to the level of a small branch called Persimmon run, about one half mile below town. The coal is here washed bare in the bed of the branch. It is only 4 inches thick, but is overlaid by from 2 to 3 feet of very bituminous shale, which gradually changes at the top to clay shale. The section here is as follows:

Hard sandstone	6 feet
Covered space	10 "
Clay shale	10 "
Bituminous shale	2 "
Coal	4 inches.

This is probably the same coal which was once opened a little above high water mark, near the mouth of the old Hawes shaft. Its position is shown in the section at this place, plate II. The coal, which is reported to have been formerly exposed in the bed of Lead creek, at the crossing of the Owensboro and Hawesville road, is also probably referable to this seam, but, relatively, it is 20 or 30 feet higher than the usual position of the seam. Beyond this, to the west or south, this coal is not again seen above the drainage in this county, and nothing is known of it.

About 90 feet above this coal, and from 40 to 50 feet below the limestone near the top of the Hawes hill, is another seam of coal, which has about the same easterly limit as the one just described, but extends considerably further to the west, above drainage. It has been seen as a "stain" at a number of places, sections at some of which are shown in the accompanying plates; but it has only been opened so that it could be well examined at one place, Mr. James Mason's bank, about six miles below Hawesville. The coal is here 24 inches thick, in addition to 6 inches of bituminous slate at the bottom. The bank is worked considerably for the supply of the neighborhood. The position of the coal is shown by a section of plate II.

This coal has not been seen west of this in Hancock county, as it probably soon passes below the drainage, but not far below; for it is seen just above low water, in the bank of Blackford creek, a short distance from its mouth, at a locality known as the Shaw Hills, in Daviess county. A section here is shown in plate III. Blackford creek is here the line between Daviess and Hancock counties. The coal was imperfectly seen here, so that no measurement of thickness could be obtained. It is reported to be nearly 3 feet thick; but the accuracy of this report is not vouched for. There is a very slight reversal of dip, which brings the coal to the drainage level here.

The western limit of this coal for Hancock county, where it lies above drainage, is a line running nearly south from Mr. Mason's, striking Blackford creek below the mouth of Caney.

The following analysis, by Dr. Peter and Mr. Talbutt, from a sample selected by the writer, shows the quality of the coal at Mr. Mason's bank. The sample was not quite satisfactory, as the coal was near the outcrop and muddy at the seams; hence, it probably contains too much ash:

Moisture	4.80	
Volatile combustible matter	38.90	
Fixed carbon	50.06	Coke 56.30.
Ash	6.24	
Total	100.00	
Sulphur	2.316	
Specific gravity	1.289	

The coal at this place has been incorrectly referred by Mr. Lyon in volume III, first series Kentucky Geological Reports, page 463, to the seam beneath the limestone at the Hawes mine hill. This seam is shown by its "stain," immediately under the limestone, in the ravine, about 50 feet above the Mason coal. Mr. Lyon is also probably mistaken in referring the sandstone at the bluffs above Mr. Mason's house to the sandstone immediately over the Main Hawesville coal, and stating that the coal is here not more than 30 feet below the surface. The position of the sandstone is shown in a section of plate II. The base of it is less than one hundred feet below the Hawes Hill limestone, and hence more than that distance above the Main Hawesville coal.

Next above the just described coal lies the coal which has been already so many times referred to as occurring immediately under the Hawes Hill limestone. The eastern limit of this coal is a line running nearly south 20° west from the Ohio river, at the lower edge of the town of Hawesville, at the fold heretofore described, to the southern boundary of the county. This coal does not at any point extend far east of the Hawesville and Knottsville road; and, in an approximate way, it might be taken as the eastern limit of the coal.

To the west this coal extends to the county line and beyond. In the lower valley of Yellow creek it lies very near the drainage level, and at some places a little below it, but at no point more than a few feet. The same is true of the Blackford creek valley for some distance below the crossing of the Hawesville and Owensboro road; but lower down, at

the Shaw Hills, already referred to, this coal is above high water mark. (See plate III.)

At the Ohio river, where first seen, the coal is too thin to be of any great value. Near the old opening, at the Hawes hill, it is only 25 inches thick. At the Adams bank, two miles below, it is about the same thickness. Going south, this coal thickens, and becomes the most valuable and accessible coal of the central part of the county. Between Lead and Caney creeks, at the Wilson and Lawson banks, it is 30 and 32 inches thick, while further south, between Caney and Blackford creeks, at the H. Bruner bank, it is a fine seam of 44 inches thickness, including, however, a parting of 2 inches. South of Blackford creek, just across the line in Daviess county, near the Friendly Grove school-house, at the Duncan bank, this coal is 48 inches thick, without parting. Through all this region this coal lies well above the drainage, and can be readily mined. In the western part of the county it has been rarely opened; and, although the limestone which overlies it is often seen, the coal is rare in outcrop. A drift was run in this coal at the Shaw Hills, on Blackford creek, but had fallen in at the time of visit, so that the coal could not be measured. It is reported between 2 and 3 feet in thickness. The section here is shown in plate III.

The following analyses, by Dr. Peter and Mr. Talbutt, from samples taken by the writer, show the character of this coal:

	I.		II.	
Moisture	5.40		6.20	
Volatile combustible matter	34.80		41.90	
Fixed carbon	49.30	Coke 59.80.	47.40	Coke 51.90.
Ash	10.50		4.50	
Total	100.00		100.00	
Sulphur	2.398		3.743	
Specific gravity	1.353		1.285	

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No. 1 is from Milton Lawson's bank, near Hawesville and Knottsville road.

No. 2 is from the Duncan bank, Friendly Grove schoolhouse, Daviess county.

The limestone above this last coal has been referred to several times. It is quite persistent in occurrence, although varying locally in thickness. At places near the river, near its eastern limit, it is 8 or 10 feet in thickness; but toward the west it decreases to 2 feet. Where it is thick, the bottom is usually cherty, but where thin, it is a moderately pure, dark-colored limestone.

About 20 to 30 feet above the last described coal lies another, which is as yet known only at a few places in the western portion of the county; but it has been seen frequently enough, and its place so well determined, as to justify giving it a place in the general section. It is the coal at the base of the hill below the old Lewisport mines, the coal reported to have been found in the well at Mr. J. Colbert's, the coal at the old lick above Mr. D. Driscoll's, and the coal showing as a "stain" in the roadside at the crossing of Blackford creek by the Owensboro and Hawesville road. It is also probably the coal reported by Gen. Adair, of Hawesville, as occurring above the limestone in the Hawes hill.

At none of these places is it more than 18 inches thick; and hence it is not probable that it will be found thick enough to be of economic value. It is not worked in this county.

We now come to the coal known as the Lewisport seam, which is the most valuable coal of the western part of Hancock county, and perhaps the most trustworthy coal as regards thickness of any in the county. It is called the Lewisport seam, from the fact that it was formerly mined back of, and shipped from, the place of that name. Its position is 40 to 50 feet above the last described coal, or about 275 feet above the Main Hawesville seam.

The field of the coal lies in the ridge between the waters of Blackford and Yellow creeks, and out on the spurs toward

Blackford creek. Unfortunately, this area is not large in Hancock county, as it embraces but a few square miles.

To the east, it does not extend beyond the head of the South Fork of Yellow creek, as the rise of the rocks in this direction brings the coal to the tops of the hills. To the west, it extends to Blackford creek, the boundary of the county. The dip of the coal is, to the west, from 25 to 50 feet to the mile, this latter, however, being probably local, as the rate was only observed at one place. Some levels have been run at the different exposures of this coal, partly by Mr. Page and partly by the writer, for the purpose of determining the dip. At the Robert Estes bank, which is the most eastern opening at present, the coal is 101 feet above high water in the Ohio river. From here south, the coal lies nearly horizontal or rises a little. At the Colbert bank the coal is at the same level; at the Billings bank it is 6 feet higher, while at Wm. Richardson's, on the Owensboro and Hawesville road, it is 114 feet above high water. At G. W. Lott's, west of this place, on the same road, the coal is only 56 feet above high water, and at the old Lewisport mines it is 59 feet above.

This coal has been mined at a number of places, both on the Yellow and Blackford creek slopes, and is usually from four to four and one half feet thick, without parting of any appreciable thickness. Several of these openings have been mentioned above. But few of them are now worked, and these only for local supply, as no coal is now shipped by the river. The old Lewisport mines, whence the coal was shipped, were opened in a very narrow ridge, where the coal was soon exhausted. There is an abundant supply in the main ridges a little further back from the river, where the coal is regular in thickness, and situated very favorably for cheap mining.

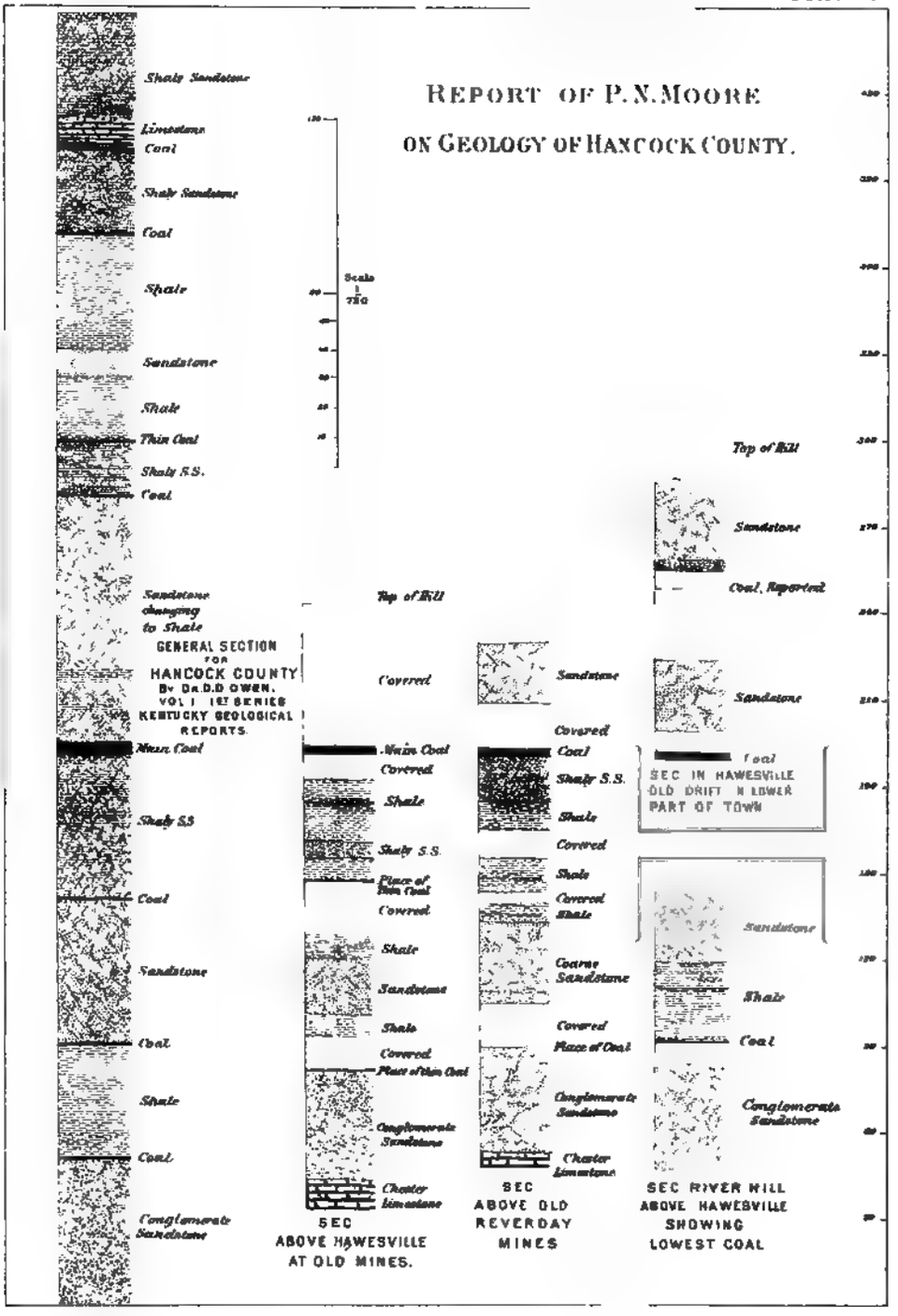
The following analysis, by Dr. Peter and Mr. Talbutt, of a sample of coal collected by the writer from the Estes bank, will serve to show the quality of the coal of this seam:

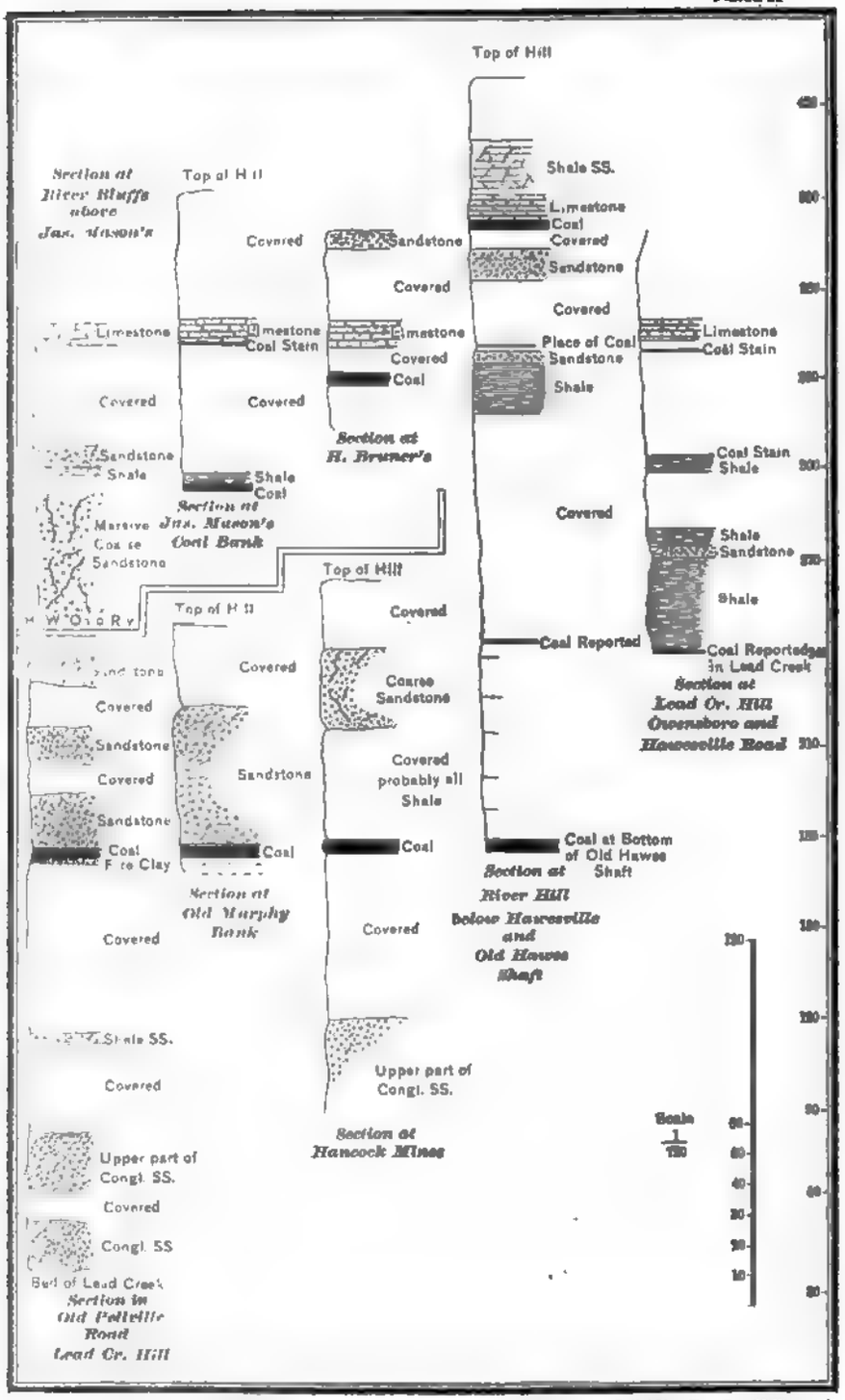
Moisture	3.50	
Volatile combustible matter	43.40	
Fixed carbon	45.56	Coke 53.10.
Ash	7.54	
Total	100.00	
Sulphur	4.155	
Specific gravity	1.323	

The coal at No. 23 of the general section, about 50 feet above the Lewisport seam, has been given a place in the section provisionally and with extreme hesitation. It is known at only one place—Wm. Richardson's, on the Owensboro and Hawesville road—where it is reported to have been cut through in sinking a well, and that it was 18 inches thick.

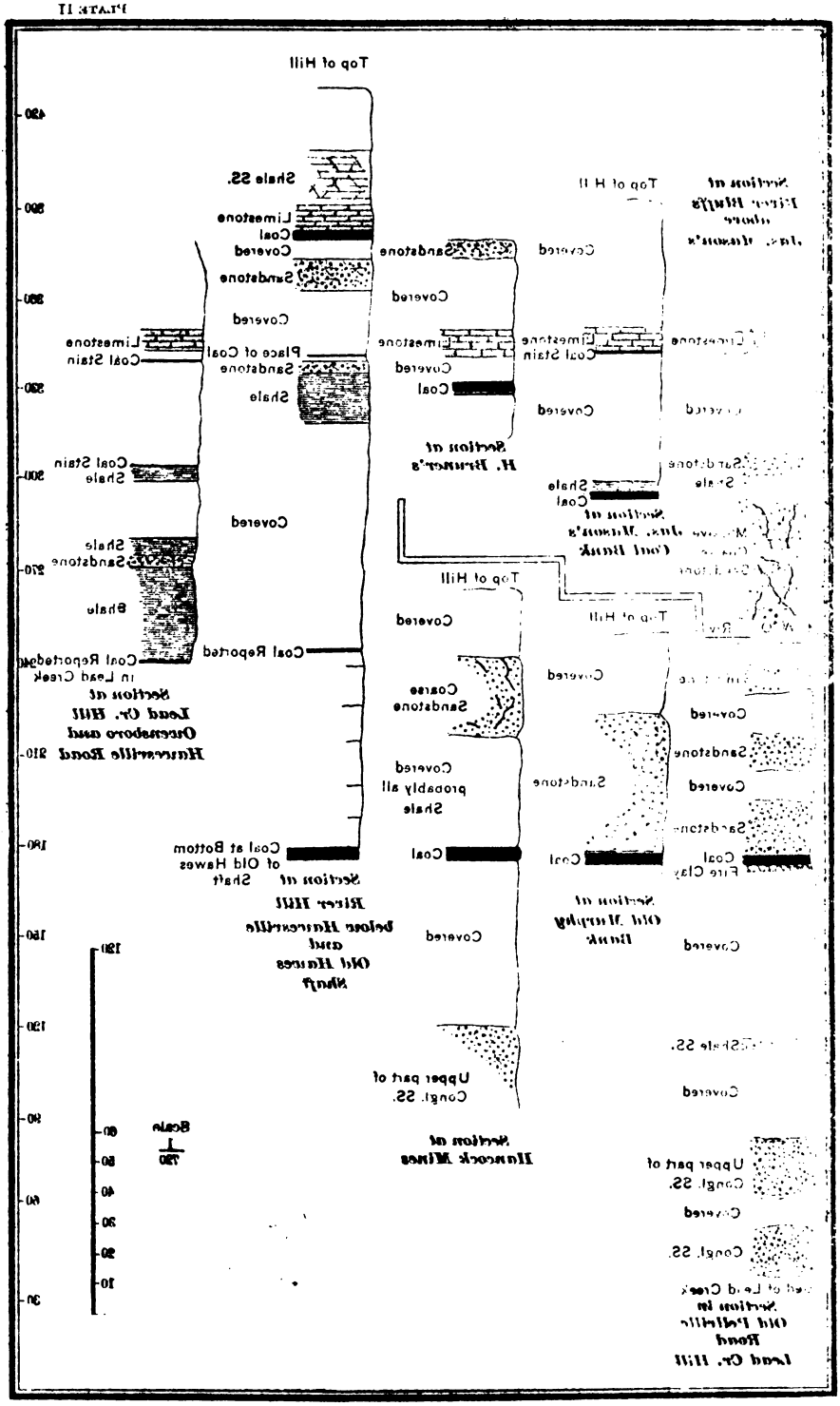
There are but few places in this county where the hills are sufficiently high to contain this coal; so that, even if it were thick enough to be workable, it could be of no economic importance.

Plate I

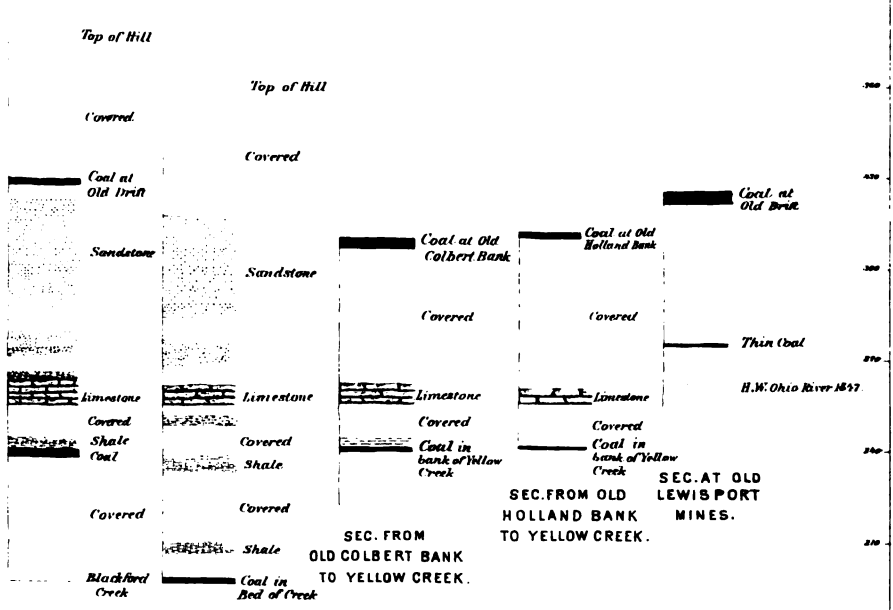

REPORT OF P. N. MOORE
ON GEOLOGY OF HANCOCK COUNTY.
Shaly Sandstone
Limestone
Coal
Shaly Sandstone
Coal
Shale
Sandstone
Shale
Thin Coal
Shaly S.S.
Coal
Sandstone changing to Shale
Main Coal
Shaly S.S.
Coal
Sandstone
Coal
Shale
Coal
Conglomerate Sandstone
GENERAL SECTION FOR HANCOCK COUNTY By Dr. D.D. OWEN. VOL I 1ST SERIES KENTUCKY GEOLOGICAL REPORTS.
Scale 1 mile
Top of Hill
Covered
Main Coal
Covered
Shale
Shaly S.S.
Place of Thin Coal
Covered
Shale
Sandstone
Shale
Covered
Place of Thin Coal
Conglomerate Sandstone
Chester Limestone
SEC ABOVE HAWESVILLE AT OLD MINES.
Sandstone
Covered
Coal
Shaly S.S.
Shale
Covered
Shale
Covered Shale
Coarse Sandstone
Covered
Place of Coal
Conglomerate Sandstone
Chester Limestone
SEC ABOVE OLD REVERDAY MINES
Top of Hill
Sandstone
Coal, Reported
Sandstone
Coal
SEC IN HAWESVILLE OLD DRIFT N LOWER PART OF TOWN
Sandstone
Shale
Coal
Conglomerate Sandstone
SEC RIVER HILL ABOVE HAWESVILLE SHOWING LOWEST COAL

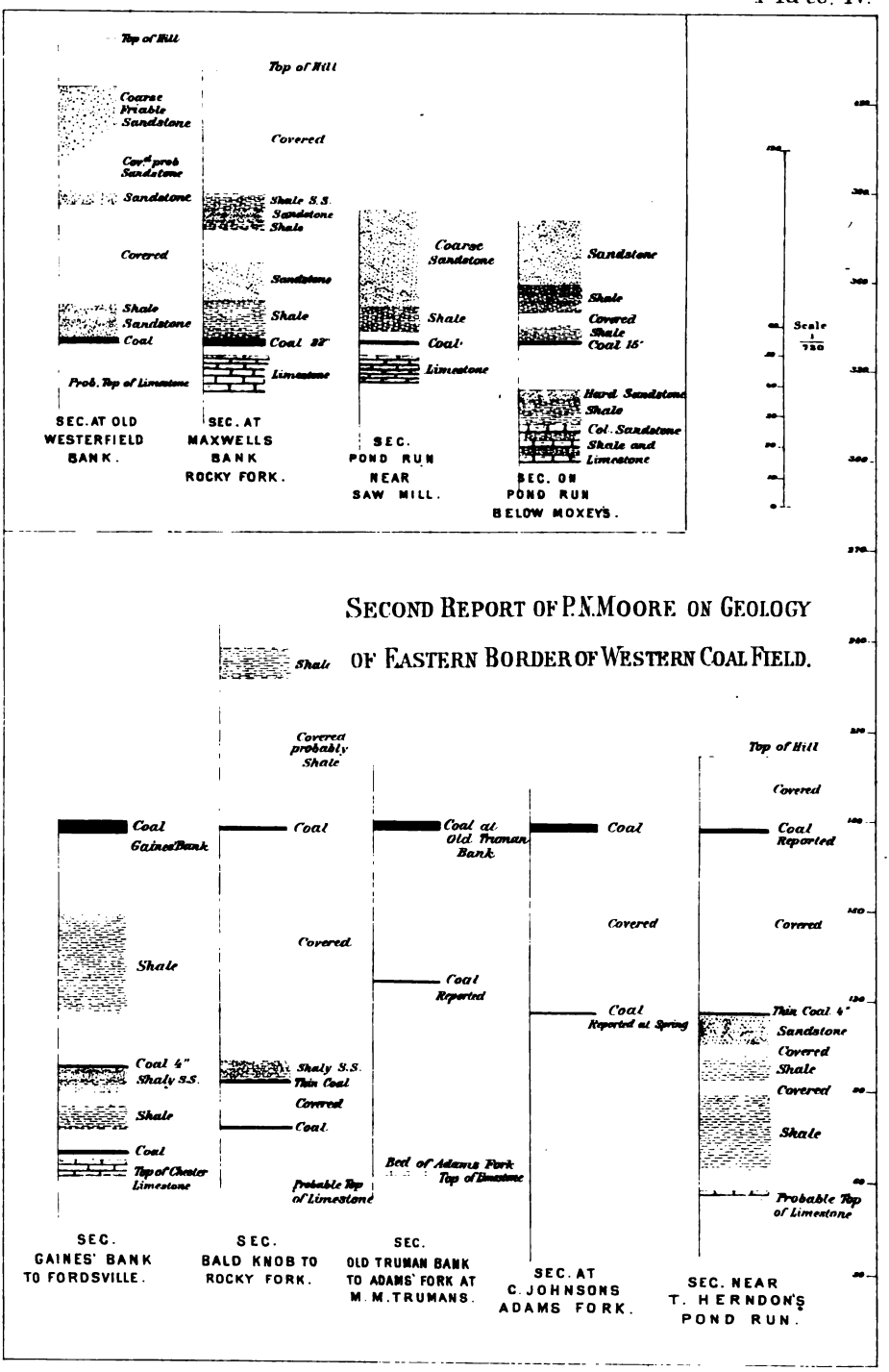


N. Y. Map and Relief-Line Eng. Co., 17 Warren St.


Top of Hill
Shale SS.
Limestone
Coal
Covered
Sandstone
Covered
Limestone
Coal Stain
Place of Coal
Sandstone
Shale
Coal Stain
Shale
Covered
Shale
Sandstone
Shale
Coal Reported
Coal Reported in Lead Creek
Section at Lead Cr. Hill Queensboro and Hawesville Road
Coal at Bottom of Old Hawes Shaft
Section at River Hill below Hawesville and Old Hawes Shaft
Sandstone
Covered
Limestone
Covered
Coal
Section at H. Bruner's
Covered
Coarse Sandstone
Covered probably all Shale
Coal
Covered
Upper part of Congl. SS.
Section at Hancock Mines
Top of Hill
Covered
Limestone
Coal Stain
Covered
Shale
Coal
Section at Jas. Mason's Coal Bank
Top of Hill
Covered
Sandstone
Covered
Coal
Section at Old Murphy Bank
Covered
Shale SS.
Covered
Upper part of Congl. SS.
Covered
Congl. SS.
Section in Old Pellville Road Lead Cr. Hill
Scale
1/720

REPORT OF P. N. MOORE
ON GEOLOGY OF HANCOCK COUNTY.




Top of Hill
Coarse Friable Sandstone
Car^n prob Sandstone
Sandstone
Covered
Shale
Sandstone
Coal
Prob. Top of Limestone
SEC. AT OLD WESTERFIELD BANK.
Top of Hill
Covered
Shale S.S.
Sandstone
Shale
Sandstone
Shale
Coal 22'
Limestone
SEC. AT MAXWELLS BANK ROCKY FORK.
Coarse Sandstone
Shale
Coal
Limestone
SEC. POND RUN NEAR SAW MILL.
Sandstone
Shale
Covered
Shale
Coal 15'
Hard Sandstone
Shale
Col. Sandstone
Shale and Limestone
SEC. ON POND RUN BELOW MOXEY'S.
Scale 1/750
SECOND REPORT OF P.N.MOORE ON GEOLOGY
OF EASTERN BORDER OF WESTERN COAL FIELD.
Shale
Coal
Gaines Bank
Shale
Coal 4"
Shaly S.S.
Shale
Coal
Top of Chester Limestone
SEC. GAINES' BANK TO FORDSVILLE.
Covered probably Shale
Coal
Covered
Shaly S.S.
Thin Coal
Covered
Coal.
Probable Top of Limestone
SEC. BALD KNOB TO ROCKY FORK.
Coal at Old Truman Bank
Coal Reported
Bed of Adams Fork
Top of Limestone
SEC. OLD TRUMAN BANK TO ADAMS' FORK AT M.M.TRUMANS.
Coal
Covered
Coal
Reported at Spring
SEC. AT C. JOHNSONS ADAMS FORK.
Top of Hill
Covered
Coal
Reported
Covered
Thin Coal 4"
Sandstone
Covered
Shale
Covered
Shale
Probable Top of Limestone
SEC. NEAR T. HERNDON'S POND RUN.

GEOLOGICAL SURVEY OF KENTUCKY.

N. S. SHALER, DIRECTOR.

ON THE GEOLOGY

OF THE

REGION ADJACENT TO THE EASTERN BORDER

OF THE

WESTERN COAL FIELD,

FROM THE

LOUISVILLE, PADUCAH AND SOUTHWESTERN RAILWAY TO THE OHIO RIVER.

BY P. N. MOORE.

PART XI. VOL. IV. SECOND SERIES.

STEREOTYPED FOR THE SURVEY BY MAJOR, JOHNSTON & BARRETT, YEOMAN PRESS FRANKFORT, KY.

423 & 424

ON THE GEOLOGY OF THE REGION ADJACENT TO THE EASTERN BORDER OF THE WESTERN COAL FIELD, FROM THE LOUISVILLE, PADUCAH AND SOUTHWESTERN RAILWAY TO THE OHIO RIVER.

The work of tracing the eastern outline of the western coal field was performed by a party in charge of Mr. S. S. Lyon, in the year 1859, while the former Geological Survey of the State, under direction of Dr. D. D. Owen, was in progress, and a report was published in volume IV, first series Kentucky Geological Reports. A skeleton map, which was constructed at the same time, has, however, never been published, but has remained in the archives of the Survey to the present time.

The work by this party was, however, from necessity, done in so rapid a manner that it could not be detailed. Mr. Lyon himself states (vol. IV, p. 586) that a large portion of the margin of the coal measures was only approximately determined.

The topographical work was confined to mapping some of the principal roads near the coal field margin—some inside of it and some beyond. The geological observations seem likewise not to have extended over an area of any great width, nor to have embraced the country between the mapped roads.

For these reasons the Director of the Survey ordered the re-survey of this area during the past season, extending the examinations to the west within the coal field, in most cases beyond the point where the Sub-carboniferous rocks disappear beneath the drainage, and far enough to obtain some knowledge of the position and character of the coals which are near the margin.

The topographical party under Mr. W. B. Page extended its operations as far to the west as the geological examina-

tions, mapping all the roads and principal streams. It is owing to their work that the outline can be delineated with any detail.

In speaking of the outline of the coal field in the following pages, the word will be used to mean the line where the coal-measure rocks first present anything like a connected body, or beyond which they are the prevailing rocks.

The term must, of necessity, be used somewhat arbitrarily, for the edge of the coal field presents an extremely broken and irregular outline, being cut through by nearly every stream and ravine, so as frequently to isolate large areas, or leave them as tongues or outliers extending out over the Sub-carboniferous rocks.

The outline or margin of the coal field, from the point south of Leitchfield, Grayson county, whence it was followed south to Green river, in the report, part I, volume II, second series Kentucky Geological Reports, turns towards the west, crosses the Louisville, Paducah and Southwestern Railroad about three miles from Leitchfield; thence runs nearly parallel to the rail-road, and not more than a half mile north of it, until a short distance beyond Caneyville, where it turns to the north. The Chester limestone is seen in the road about one half mile north of Caneyville, while a short distance beyond nothing but Sub-carboniferous rocks occur.

From Caneyville to the Falls of Rough creek the outline runs a little to the west of the Bowling Green and Cloverport road. Its distance from this road varies somewhat, but it does not cross the road, unless, perhaps, at one place on a high dividing ridge, and this even is not certain.

It is broken by the valley of Short creek, which runs entirely in Sub-carboniferous rocks from head to mouth, and again by Rough creek.

The triangular area between this road, Short and Rough creeks, is entirely detached and surrounded by Sub-carboniferous rocks; but it occurs in the direction of the principal line of outcrop, and, by position, belongs properly to the main body of the coal measures.

Near the Falls of Rough the coal measures cap the ridge to the west of, and but a short distance from, Pleasant run. Crossing Rough creek, they are first found in the Cloverport road, capping the ridge west of Rock Lick creek. From here the outline still follows closely the Cloverport road, crossing it occasionally, and often cut by the streams which the road crosses, until within a few miles of Cloverport, where it turns toward the northwest, crosses Tar Fork and a number of its branches, and reaches the Ohio river between Hawesville and Cloverport.

There are a number of outliers a considerable distance to the east of the margin as just described, but they are mostly entirely isolated, and of small extent. They usually consist of detached knobs or high dividing ridges between streams, capped with a small thickness of wasted coal-measure rocks. They do not, so far as known, carry any coal, although a few of them apparently rise high enough to hold the lowest coal; but it is probable that, even if present, the coal will be found badly weathered and worthless, owing to the slight covering above it, and the effects of exposure on all sides.

Such outliers occur on the ridge between the waters of Tewells and Long Lick creeks, between the branches of Rough creek and Clover Fork, at Sand or Pine Knob, near Eskridge's Ferry, and also south of Rough creek, between that stream and Short creek.

The Sub-carboniferous rocks are found above drainage much further to the west than the outline above described. Nearly all of the principal streams shown in the accompanying map, by Mr. Page, except in the central and western portion of Hancock county, cut their channels in these rocks.

Near the Ohio river the Chester limestone is last seen immediately below, and in contact with, the Conglomerate sandstone, about one mile above Hawesville. Indian creek runs in Sub-carboniferous rocks from head to mouth; but Lead creek, which is next below, and not far distant, does not cut below the Conglomerate. The different branches of Tar Fork all run in the Sub-carboniferous rocks.

On Sulphur Fork of Blackford creek, at Patesville, it is stated that the Chester limestone was found a few feet below the bed of the creek, when digging a water-pit for a saw-mill; elsewhere it is not seen on this stream. It is found in all the head branches of Panther creek, and extends in the main stream nearly a mile west of the Cloverport and Fordsville road before it passes below the drainage.

Crossing the divide to the waters of Adams' Fork, a branch of Rough creek, the Chester limestone is found near the heads of the main branches, except Middle Fork, which does not cut it until within about one mile and a half of Fordsville, where the top of it is exposed. It is also seen just below Fordsville, but disappears again, and is not exposed for some distance.

No exposures of the Chester limestone have been found west of Fordsville and Middle Fork.

After its junction with the Middle Fork, the main branch of Adams' Fork runs in this limestone, to its mouth.

The branches of Rough creek from the north, and those emptying above Adams' Fork, all run in the Chester rocks nearly from head to mouth.

Rough creek itself has cut a wide valley in the Sub-carboniferous rocks for its whole length, in the region under discussion. This is owing to an anticlinal or uplift in the strata, by which the Chester rocks have been raised to the present surface far inside of the coal field. The axis of the anticlinal is followed pretty closely by Rough creek, within the area covered by this report, although occasionally the creek runs in the edge of the coal measures at one side of the Chester rocks exposed. This is due to the fact that the disturbed and folded rocks are most readily worn away by the action of running water, and thus afford the easiest channel for a stream to flow along. The anticlinal, therefore, has probably been the agent which has directed Rough creek into its present course.

This anticlinal is the most important geological disturbance of this region. It completely divides the region under discussion into two parts, as the coal-measure rocks at no point

extend across it. The rocks dip away from Rough creek in both directions, sometimes quite regularly and sometimes broken by small faults.

The writer is informed by Mr. Norwood that, shortly after passing to the west of this region, Rough creek leaves the line of the anticlinal, which extends westward through Ohio county some distance to the north of Rough creek, and finally crosses Green river into Webster county. For the particulars of its course the reader is referred to the report of Mr. Norwood upon the geology of Ohio county. Enough has been stated here to show that this is a geological feature of more than local interest, if not the most important disturbance in the western coal field.

South of Rough creek all of its branches, as far west as, and including, Caney creek, have cut down to the Chester rocks. Near the railroad, on Caney creek, the rocks are so covered that it is difficult to tell at what geological level it does run, but it is not far above the Chester limestone, if any; and before it reaches its mouth, Caney creek has cut nearly one hundred feet down into the Chester rocks. Along the railroad, as shown by Mr. Norwood's section in volume I, second series Kentucky Geological Reports, the Chester limestone is found a few feet above the creek, until beyond Caneyville.

Between the railroad and Rough creek, Caney creek and the Bowling Green and Cloverport road, the coal measures cap the ridge, and toward the railroad cover most of the surface; but on the Rough creek slope they extend only over a small area on the tops of the ridges.

GENERAL GEOLOGY.

In the region under consideration there are exposed only the rocks of the Carboniferous system, including:

Carboniferous,	- -	{ Coal Measures.
Sub-carboniferous,	-	{ Chester Group. St. Louis Group.

The characteristics of these different divisions have been so fully and recently described in the reports of the Geological Survey, that it is not considered necessary here to repeat them. They will be discussed here in an ascending order.

THE ST. LOUIS GROUP.

The limestone of this group, called by Mr. Lyon, in his report (volume IV, first series Kentucky Geological Reports), "the cavernous member of the Sub-carboniferous limestone," is exposed only in the eastern portion of the region under discussion, where it is cut into by the streams, but not to any great depth. It is seen on Little Clifty creek and on Rough creek, near the mouth of Little Clifty. It also probably occurs on Short creek, its presence being indicated by the topography; but the region has not yet been examined in sufficient detail to determine with certainty if this be the case.

North of Rough creek, and as far west as the Falls of Rough, most of the streams and their branches run in the upper part of the St. Louis limestone. This is also true of the creeks flowing into the Ohio river as far west as Clover and Tar Forks, which empty at Cloverport.

In none of these cases, as already stated, is a considerable thickness of the rocks of the St. Louis Group exposed, so that it is practically of small importance. But a short distance to the east, in Breckinridge county, the St. Louis limestone is the most prominent member of the rock series.

The thickness exposed in the region covered by this report is so small, that, from natural sections alone, little could be known in regard to this limestone; but in the vicinity of Cloverport, during the oil excitement some twelve years since, numerous wells were sunk in search of oil, which penetrated deep into the St. Louis rocks. Of these, unfortunately, the records of only two have been obtained. It has been impossible, though diligent efforts have been made, to find any trace of the others, as the individuals who sank the wells and kept the records, if any were taken, have left the

region, and no trace of them can be found. This is greatly to be regretted, as the records of all these wells would furnish valuable information in regard to the stratification below the present drainage surface of the country, which can be obtained in no other way.

Sections obtained by boring, unless made for the express purpose of ascertaining the character of the rocks, are always liable to a certain amount of error from the difficulty of recognizing the material passed through by the drill. This liability to error is greatest where passing through thin strata, as the line of transition from one to the other is not easily determined, owing to the mixing of the pulverized material by the drill. When these allowances are made, however, these records are of great value.

The two following sections are the records of wells sunk by the Breckinridge Petroleum Company, and were kindly furnished for publication by Mr. E. D. Tyler, of Louisville. They were both sunk in Breckinridge county, on the waters of Tar Fork, and the starting point in both cases was near the base of the Chester Group. The records are given as reported, although in some cases slightly altered in phraseology, and abbreviated. The remarks in parentheses are by the writer:

THE NEWTON WELL, HONEY LOCUST BRANCH OF TAR FORK.

	Thickness, feet.	Total depth.
Soil	7	7
Sandstone	2	9
Limestone	10	19
Shales and thin sandstones	30	49
Sandstone	24	73
Limestone	9	82
"Slate and soapstone" (shale)	41	123
Limestone	33	156
"Slate and soapstone" (shale)	23	179
Limestone	15	194
Sandstone	3	197

It is stated by Mr. J. T. Goff, of Cloverport, that this well was afterwards sunk to a total depth of nearly 300 feet; but no records of it have been found, other than as above given.

THE GABBERT WELL, TAR FORK, ABOUT ONE MILE BELOW TAR SPRINGS.

	Thickness, feet.	Total depth.
Limestone	10	10
Shale	3	13
Limestone	42	55
Shale	50	105
Limestone	37	142
"Red sandstone"	10	152
Hard shale	15	167
Limestone	23	190
Hard shale	15	205
Limestone	30	235
Shale	10	245
Limestone	87	332
Sandstone	2	334
Limestone	21	355
Shale	5	360
Limestone	11	371
Shale	7	378
Limestone	13	391
Shale	1	392
Limestone	4	396
Shale	3	399
Limestone	91	490
"Hard grey granite?" (This is evidently a mistake. It is probably a stratum of flinty limestone)	10	500
Limestone	38	538
"Limestone and sandstone"	47	585
Limestone	16	601
Shale	6	607
Sandstone	7	614
Limestone	3	617
Sandstone	7	624
Limestone	6	630
Sandstone	2	632
Limestone	5	637
Sandstone	2	639
Limestone	38	677
Sandstone	1	678
Limestone	7	685
Sandstone	3	688
Limestone	13	701
Shale	27	728
Limestone	9	737
Shale	30	767

In the above record there is evidently a serious mistake in the stratum recorded as "granite," for there is certainly no such rock in this region. It is probable that it is a stratum of unusually hard limestone, which the person in charge of the well dignified with the name of granite.

If the above records are to be depended upon, they prove that the St. Louis Group, instead of showing massive, homo-

geneous character, which it possesses further south and southeast, is here formed of limestones interstratified with numerous thin beds of shale and sandstone, and nowhere shows an unbroken limestone of more than 150 feet thickness. For the present, and until this group can be studied in more detail in Breckinridge and Meade counties, to the east of this region, this conclusion must be regarded as tentative, as it indicates a marked change from the character of the group as known at other places. Dr. Owen, however, in volume II, first series Kentucky Geological Reports, page 92, calls attention to this same feature in Breckinridge and Meade counties.

THE CHESTER GROUP.

This group retains throughout the characteristics described in the previous reports of the Geological Survey by Mr. Norwood and the writer.

It consists of sandstones, limestones, shales, and marly shales in great variety, both as to thickness and order or position. The strata which compose it are very changeable and uncertain in their occurrence—no one stratum, except perhaps the Big Clifty sandstone, which marks the base of the series, seeming to be persistent over any wide area.

For this reason no general section of the members of this group can be given which will be more than locally accurate, and none has been attempted. In a general way the rocks retain the character shown in the sections of Mr. Norwood's report along the railroad, and in the sections for the region south of Leitchfield and Grayson Springs. (Part II, volume II, second series Kentucky Geological Reports.) There is a great prevalence, especially toward the upper part of the series, of thin-bedded and shaly rocks, differing from the more massive character which the members of this group present further south, on Green river.

In the southern part of this region, along the railroad and for a short distance to the north, the sections above referred to, which have heretofore been published, illustrate the character of the stratification. The shales, marly shales, and

marls are the most abundant rocks. Further north, in the valley of Rough creek, on both sides of that stream, these rocks are not so conspicuous, and where present are thin; and we have a greater prevalence of thin limestones and sandstones.

Still further north, in the immediate drainage of the Ohio river, the shales and marly shales are again found abundant, and of considerable thickness; in fact, they are the most conspicuous members of the series in this vicinity.

The following section, near the Bowling Green road, just after the crossing of Tar Fork south of Cloverport, is fairly typical of the upper portion of the Chester Group, and shows the great abundance of these shaly rocks:

SECTION.

Top of hill.	
Covered space; wasted coal-measure sandstones?	50 feet.
Limestone	25 "
Shale	15 "
Thin limestone	1 "
Shale, upper part marly	8 "
Limestone, very silicious	10 "
Dark shale	11 "
Limestone	4 "
Shale	6 "
Green marly shale	14 "
Shale	25 "
Covered space	20 "
Sandstone	25 "
Covered (probably sandstone)	15 "
Limestone	25 "
Covered, limestone seen at intervals	45 "
Red and green marly shale	4 "
Covered space	25 "
Tar Fork.	

High water mark of the Ohio river will probably come within a few feet of the last exposure of marly shale in the above section.

The heavy sandstone at the base of the Chester series, which has been called by Mr. Norwood the Big Clifty sandstone, is persistent throughout this region; more so apparently than any other stratum of the group. It is found from 40 to 100 feet in thickness, and is generally exposed wherever the streams have cut into the lower part of the series. It is called by Mr. Lyon the "Lower Tar Spring Sandstone." It is noted for the great number of tar springs which issue

from its base. It is the sandstone which occurs in such imposing exposures at the Tar Springs south of Cloverport, in Breckinridge county. It is also the sandstone which is seen on the Ohio river below Cloverport. It is here an excellent building stone, and has, in former times, been extensively quarried and shipped away. Part of the rock for the locks on Green river was obtained here.

The great prevalence of tar springs issuing from this sandstone gave encouragement to the idea that oil would be found in this region in large quantities; but beyond this single fact there was nothing which points to any such conclusion.

THE LEITCHFIELD MARLS.

The green and red marly shales, containing a considerable per centage of potash, which are found in the upper part of the Chester Group, and which occur in such abundance in the vicinity of Leitchfield, Grayson county, that they have been called by the Director of the Survey the Leitchfield Marls, extend over a large part of this region. They may be said to follow the distribution of the shaly and thin-bedded strata as already given. Near the railroad they are abundant. In the central part of this region, on Rough creek and its tributaries, they have not been so frequently seen, and where they do occur, they are thin. Toward the Ohio river, they are again abundant and of great thickness. On nearly all of the branches of Tar and Clover Forks they are frequently exposed. The section just given shows them occurring at several different levels.

At a locality in the edge of Hancock county, about three miles from Cloverport, known as the Buffalo Wallow, there is a remarkable natural exposure of these marly shales, showing a thickness of thirty feet or more. These shales are reported to extend several miles to the south of this locality, still retaining this thickness.

There is, therefore, in the aggregate, in this region, an enormous quantity of these marly shales, lying close to the surface, and very accessible. It is greatly to be hoped that

some economical process will ere long be discovered, by which the potash, their valuable fertilizing ingredient, can be rendered soluble, and therefore immediately available. When this can be cheaply accomplished, these beds will be of the greatest value to this country as a source from which to draw the fertilizers which shall renew the worn tobacco lands. They exist in such quantities, and are so accessible, that they will cost but a trifle; and the only expenses attending their use will be the transportation and preparation.

THE CHESTER COAL.

The thin coal in the Chester rocks, which is so generally found in the region south of this, is also quite persistent here. It has been seen at a number of places, and is reported at many more.

Dr. Owen and Mr. Lesquereux, in volumes II and III, first series Kentucky Geological Reports, refer to two coals in the Sub-carboniferous rocks, and state that they are sometimes as much as ten inches in thickness; but the writer has seen none of more than three inches.

Although nowhere of economic value, very many attempts have been made to work these coals, and even yet time and money are occasionally wasted in digging into them at newly-discovered out crops, in the vain hope of finding them of workable thickness—a hope which, it is unnecessary to repeat, will never be realized. It is useless to search for workable coal in the Chester rocks.

THE COAL MEASURES.

Within the area covered by this report, not including Hancock county, which will be discussed in a report devoted to the whole county, we have shown a total of about 180 feet thickness of coal measures, or perhaps 200 feet in some of the highest knobs. A thickness of 150 to 180 feet is only attained in the western part of this region, while to the east it gradually decreases until only the tops of the hills are covered with a thin cap of wasted coal measures.

The rocks vary so greatly in thickness, are so uncertain in occurrence, and, withal, are so rarely well exposed, that it is difficult to give a general section which will hold true over any considerable area. Nevertheless, with the qualification that it only shows the stratification in a very general way, the following section is given:

GENERAL SECTION.

1.	Covered space, probably shales	30 to 60 feet.	
2.	Coal	1 to 4 "	
3.	Covered space, probably shale	50 "	
4.	Coal		4 to 18 inches.
5.	Sandstone	10 to 30 "	
6.	Shale	0 to 20 "	
7.	Coal		0 to 4 "
8.	Shale	15 "	
9.	Coal		12 to 26 "
10.	Sandstone and shale	0 to 30 "	
	Top of Chester limestone.		

The plate of sections accompanying this report shows more accurately the position and changes of these rocks.

It will be noted that no reference is made to the Conglomerate in the above general section. This rock is not recognized in this region until near the Ohio river, in Hancock county. At some places it seems to be represented by a coarse, friable, micaceous sandstone; at others it is entirely wanting; and we have the lowest coal resting almost immediately upon the Chester limestone.

In the region to the south of this, which was embraced in the report, part II, vol. II, second series Kentucky Geological Reports, there is no rock which can be certainly identified as the Conglomerate for a distance of several miles south of the railroad. Its disappearance is nearly coincident with the occurrence of the frequent small disturbances in, and the sudden rise of, the Chester rocks toward the railroad. It is possible that this may be due to the fact that, where the Conglomerate is present, the faults and disturbances are not noticed; but the fact remains. The Conglomerate is, therefore, wanting over nearly all the area in which the Chester rocks are known to be considerably disturbed. Whether this has any bearing upon the question of the age of these disturbances, it is difficult to state. It certainly indicates a

cessation, over a large district, of the disturbed waters and rushing currents which accompanied the deposition of the Conglomerate, and a prevalence of more quiet conditions; but whether this was accompanied by a greater submersion, or a previous elevation of this region, is not yet certain.

This region, as is also true of other portions of the margin of the western coal field, shows a decided thinning of the coals toward the margin. With perhaps one or two very limited exceptions, the lowest coal is not found workable near the edge of the field. The most prominent exception to this rule is the Breckinridge cannel coal, which will be referred to in another place. The coal in the upper part of the general section is not found until some miles within the coal fields, and then it is not always workable; while the coals between are nowhere workable within the present field under discussion.

This fact has an important bearing upon the question of the former connection of the eastern and western coal fields, in that it indicates the original termination of the coal field by a natural thinning out of the strata along a line probably to the east of the present margin, which has retreated to its present position under the influence of erosion.

It is the prevalent opinion among many western geologists, at the present time, that if the eastern and western coal fields ever were connected at all, it must have been around the southern end of the Cincinnati anticlinal.* At present the least distance between the two fields is about 60 miles—from the outliers of the western coal field in Edmonson and Hart counties to those of the eastern field in Clinton and Wayne counties. The character and position of the strata in Edmonson county, at the extreme southeastern corner of the western coal field, more closely resemble the rocks of a similar horizon in the eastern field than at any other point on the margin of the western field. In fact,

*While this is indeed the prevailing opinion among geologists, I have no longer any doubt that it is entirely an error, and that the eastern and western coal measures were once connected over a large part, if not the whole, of the Cincinnati axis. The evidence will be given in the third volume of this series of reports and in the second volume of Memoirs. N. S. S.

going toward the Ohio river, the character of the section changes rapidly, until it bears hardly the slightest resemblance to the rocks at the margin of the eastern field.

COAL.

It will be observed that there are four seams of coal included in the general section; but one of these, at No. 7 of the section, is so thin, and so rarely occurs, that it was a question whether it was worth a place in the general section, and it was only admitted after considerable hesitation. It will not be numbered.

The coal at No. 4 of the general section has been seen at few places, but it has been reported at a number of others, so that finally it was considered best to give it a place in the section. It is of no economic importance, as it has never been reported of more than eighteen inches thickness, and has been seen as thin as four inches.

The coals at the base and at the top of the general section are the most regular in their occurrence and position.

The equivalency of these coals with the seams of other parts of Western Kentucky has not been conclusively determined; for this section does not closely resemble any of the heretofore published sections of Western Kentucky coals. It is indeed doubtful if any true equivalency over a large area can be asserted. It sometimes happens that a few coal seams are persistent, and hold the same positions with reference to each other for long distances; but this is rarely true for the majority of the coal seams of any one region. Increasing acquaintance with the coal measures of the State only strengthens the conclusion that the most trustworthy of coal seams are subject to great changes of position and character, and that continental equivalencies, such as were thought to be traced between the coals of Western Kentucky and Pennsylvania, by members of the former Geological Survey of this State, are as yet unproved.

Nevertheless, it is desirable to identify the coals over as large an area as possible. Using the temporary method of

designating the coals by letters, suggested by Mr. Norwood, and referring to his general section of the coals of the western field along the line of the railroad, part VI, vol. I, second series Kentucky Geological Reports, the probable equivalencies of the coals in this region are as follows:

No. 2 of the general section, coal H.
No. 4 of the general section, coal K.
No. 9 of the general section, coal L.

Of these, coals L and K correspond very well with the sections published by Mr. Norwood, while coal H is much nearer to the Chester limestone than in his section, but is probably the same coal.

Coal L covers, of course, by far the largest area of any in this region; but it is usually too thin to be worked profitably, as it ranges in thickness from one to two and one half feet, the latter thickness being decidedly the exception. The position of this coal is shown by the sections of the accompanying plate. It is sometimes found resting almost immediately upon the Chester limestone, with only its fire-clay between, while at other places a thickness of thirty feet of sandstone or shale intervenes. In the central part of this region, in the valley of Rough creek, the distance of the coal above the limestone is usually less than fifteen feet, while toward the railroad and the Ohio river it is greater. It has been opened at many places for local blacksmith's use; but the openings have mostly fallen in, so that good exposures of the full thickness of the seam are rare, and in a majority of cases the thickness has been taken as reported; but as this is a matter in which the tendency of reports is not to underrate the thickness, and as in none of these places has the coal proved thick enough for profitable underground working, it is believed that the value of this coal has not been underestimated.

The character and thickness of this coal along the railroad have been stated in Mr. Norwood's report, before referred to, so that it is unnecessary here to say anything further in regard to it. From Caneyville east, as indicated already in the statement of the position of the margin of the coal field,

this coal will only be found a very short distance north of the railroad.

Between the railroad and Rough creek very little is seen of this coal. It is opened by a drift near the Falls of Rough, at what is known as the Smith or Allen bank, on land belonging to Mr. L. Green, where it shows a thickness of 25 inches, without parting, of coal rather too soft, but quite free from sulphur.

The following analysis, by Dr. Peter and Mr. Talbutt, shows the character of this coal:

Moisture	6.50	
Volatile combustible matter	30.04	
Fixed carbon	55.54	Coke 63.46
Ash	7.92	
Total	100.00	
Sulphur	1.972	
Specific gravity	1.343	

The exact distance of this coal above the Chester limestone was not determined, for it lies in a position near the top of the ridge, and at a considerable distance from any outcrop of the limestone; but it is probably not far above. The ridge in which the coal occurs rarely rises more than 75 feet above the Chester limestone.

Between Rough creek and the Ohio river coal L has been seen at many places, a number of which are shown in the plate of sections accompanying this report. Near the margin of the field it is 20 to 30 feet above the Chester limestone, but to the west it is nearer. It has been opened on Pipe run, at the Shreve bank, and at a number of places in the ridge at the head of that stream. Its thickness was not shown at any of these places, but it is not reported at more than two feet. On Pond run it has also been found at many places. Here it is nearer the limestone, being rarely more than fifteen feet above it, and sometimes not more than five. The thickness is reported from one to two feet. On Adams' Fork, below Fordsville, the coal is found resting almost immediately

upon the Chester limestone, with nothing but a thin fire-clay intervening. The coal is here reported one foot thick. Toward the head of Adams' Fork, and across the dividing ridge, on the head branches of Panther creek, this coal is not so well known. On the branch of Adams' Fork, above Fordsville, it is found close to the limestone in two or three places, and toward the head of this branch, near Mr. J. Newton's, a cannel coal or cannel shale seems to occupy this level. The exposure at this place was very imperfect, so that little could be learned as to either quality or thickness. It is probable that this is near the beginning of the field of the cannel coal, which, on Tar Fork, at the Breckinridge mines, undoubtedly occupies the horizon of coal L.

Coal K, as already stated, is usually so thin that it is of no economic importance. Along the railroad it is thicker than in any other portion of this region. At other places it is not known of more than eighteen inches. Very few exposures of it have been seen, so that nothing is known as to its quality.

Coal H, at the top of the general section, is the highest near the margin of the coal field. Its position is from one hundred to one hundred and twenty feet above the Chester limestone, in the vicinity of Fordsville, where it is best known; but south of Rough creek, near the railroad, this distance is greater. This coal is only found in the western part of this region, where the Chester limestone is near or below the drainage. Its thickness varies from one to four feet; but it is more often a fine workable seam than any other of this region.

Between Rough creek and the railroad this coal has been seen at few places. It has been opened at many, but these openings have fallen in, so that little could be learned as to thickness or quality. This is probably the coal at Laban Wright's, near Rosine Station. Here it was imperfectly seen, but a total thickness of three feet six inches was reported. It has also been opened at a few localities in the ridge on both sides of Caney creek. It will not be found far to the

east of that stream; but there is reason to expect that it will be found, whenever sought at its proper level, in the ridge to the west.

North of Rough creek, for several miles, its most easterly limit is the ridge between the branches of Adams' Fork, Rocky Fork, and Pond run. Toward the head of Pond run the hills do not rise as fast as the rocks, and they are soon too low to carry this coal; but we find it in the next ridge to the west, between the east and middle branches of Adams' Fork. It also is found in the ridges between the forks of Panther creek and between that stream and Tar Fork, south of the Breckinridge mines. In general terms it may be said that its eastern limit here is from one to two miles east of the Cloverport and Fordsville road.

This coal is seen at its best at the Gaines bank, near Fordsville. It here is 51 inches thick, including 3 inches of slate. At places the coal measures less than this, but it will average nearly 4 feet in thickness. Its quality is shown by the following analysis, by Dr. Peter and Mr. Talbutt, from a sample collected by the writer:

Moisture	6.10	
Volatile combustible matter	37.50	
Fixed carbon	50.46	Coke 56.40.
Ash	5.94	
Total	100.00	
Sulphur	3.002	
Specific gravity	1.310	

This coal is also known at other places near Fordsville, where it has been formerly worked, but is not now well shown at any of them. It is reported between three and four feet thick. Toward the east, in the last ridge where it is found, it is thin. To the west, near the Hawesville and Hartford road, which is as far as the present observations extend, it is also thinner. The dip of the coal is here decidedly to the west, and it is much lower than near Fordsville. It has

been opened by Mr. Reynolds near Zion Church, and is the upper of two coals once opened near Brooks' Mill.

North of Fordsville, in the ridge just east of the Fordsville and Cloverport road, the coal was formerly worked, and is reported of a good thickness; but nothing can now be seen of it. On the head of Panther creek, near the road, the coal was seen by the writer nineteen inches thick. It is also reported in the ridge between Tar Fork and Panther creek, south of the Breckinridge cannel mines.

IRON ORES.

In general this region does not seem to be so rich in the iron ores, near the base of the coal measures, as that further south. They have been occasionally seen, but are usually so thin and silicious as to be of little value. The only places worthy of notice occur in the road south of Cloverport. One of these, known as the "Iron Ore Hill," about five miles from Cloverport, is a high knob covered with an abundance of sandy limonite, which, however, is so silicious as to be of no value. The other occurs about five miles from the Falls of Rough, near Mr. Howard's. There is here in the road an exposure of limonite which is of very good quality, but seems to be deficient in quantity. It is possible that a more detailed and thorough examination than could be given to it at this time would prove it to be more extensive than now supposed; but the indications are that it is limited in its horizontal range.

LEAD ORES.

In many localities throughout this region, especially in the Chester rocks, small specimens of galena, or sulphide of lead, are found. They are generally found in the clay, but sometimes in thin seams in the Chester limestone. The quantity, however, is never sufficient to offer any encouragement whatever to the theory that the ore will prove abundant enough for profitable working. The reverse of this is true; and it is not probable that the quantity is at any place sufficient to render it valuable, and all time and money expended in searching for and developing these deposits will be wasted.

GEOLOGICAL SURVEY OF KENTUCKY.

N. S. SHALER, DIRECTOR.

ON THE GEOLOGY

OF PORTIONS OF THE

UPPER CUMBERLAND RIVER VALLEY,

IN

BELL AND HARLAN COUNTIES.

BY A. R. CRANDALL AND P. N. MOORE.

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ON THE GEOLOGY OF PORTIONS OF THE UPPER CUMBERLAND RIVER VALLEY, IN BELL AND HARLAN COUNTIES.

During the summer of 1876, some time was spent by the writers in the country drained by the upper Cumberland river, for the purpose of constructing the geological sections accompanying this report, and of which it is chiefly explanatory, inasmuch as no detailed discussion of the geology of this valley can be attempted, until the whole of it shall have been thoroughly examined.

The first and principal section (plate I) is from Cumberland Mountain, at Chadwell's Gap, to Straight creek, crossing Pine Mountain a short distance below the mouth of Browney's creek. The course of this section line is about N. 40° W., and it follows in a general way the direction of Browney's creek, crossing Brush Mountain and various spurs of the Black Mountains.

The measurements upon which it is based are all instrumental. The survey of Browney's creek, by which the horizontal measurement of the central portion of the section was determined, was by Mr. E. Underwood, jr. The vertical sections of horizontal coal-measure strata in the Black Mountains were made with an aneroid barometer.

Time failed for the construction of a complete section across the valley near Mt. Pleasant, but a section of the Cumberland Mountain at Crank's Gap was carefully measured, and is given herewith (plate II), as also a number of sections (plate III) of the coal-measure rocks in the Black Mountains, near Mt. Pleasant, Harlan county.

The section at Crank's Gap is from instrumental measurements by the writers, except the horizontal and vertical

distances from Crank's Gap to the "Poor Valley," on the Virginia side of the mountain, which were determined by Mr. C. Schenk.

The valley of the Cumberland river above Pineville, where the river cuts through and leaves the Pine Mountain, on its way to the Ohio, is one of the long, straight, and narrow Appalachian valleys which are so characteristic of the topography of East Tennessee and Southwestern Virginia. It owes its shape to the same cause — the long parallel mountains which determine the course of the stream. In this case the mountains which bound and determine the valley are the Cumberland and the Pine, the last to the northwest of the Appalachian series of mountains.

The Cumberland river, from the head of its longest and main branch, the Poor Fork, flows close to the foot of the Pine Mountain, never leaving it for any great distance. It therefore receives no branches of any size from the northwest, all of its tributaries flowing into it from the area between the river and the Cumberland Mountain. Its principal tributaries are Clover and Martin's Forks. Yellow, Browney's, and Puckett's creeks also drain a considerable area of the valley. Above the mouth of Clover and Martin's Forks the river is known as the Poor Fork.

From the section (plate I) it will be seen that the Cumberland valley or basin is a synclinal valley, although the mountains which terminate it on either side are of very different ages of elevation. The evidence of this statement will be referred to further on. The Cumberland and Pine Mountains, which constitute the edges of this basin, are formed of upturned strata, of age from the Carboniferous to the Silurian, those on the Cumberland dipping to the northwest, passing beneath the surface, and reappearing on the Pine Mountain, where they dip to the southeast.

The Black Mountains, which is the term applied to the palmate mountains lying between the Cumberland and the Pine, are formed of horizontal coal-measure strata, the low-

est of which are geologically above the highest of the Cumberland and the Pine Mountains.

Brush Mountain, through which the section (plate I) passes, is analogous in its structure to, and is really at one point a part of, the Cumberland. It was probably formed at the same time and by the same force which elevated the Cumberland Mountain to such a height. It is but a few miles in length, and lies parallel to Cumberland Mountain. It is joined to, and identical with, it at the head of Martin's Fork and Shillaleh creek, which flow in opposite directions, and separate the two mountains by narrow valleys. The section (plate I) crosses Martin's Fork near its head.

The Conglomerate, or rather the members of the Conglomerate series at the base of the coal measures, are the determining rocks, of greatest topographical value, in the three mountains, the Cumberland, Brush, and Pine.

The Cumberland Mountain is the wasted edge of what was once a grand anticlinal arch, reaching nearly to the Holston river. Since its elevation, therefore, Cumberland Mountain has, in consequence of erosive action, retreated a distance of several miles. The evidence of this, and the discussion of the dynamical geology of this region, will be found in the reports of the Director of the Survey; so that the mere statement of the fact is all that is necessary here.

Brush Mountain, as shown by the section (plate I), is formed by the uplift of, and a great fold in, the Conglomerate series, by which these beds have been raised nearly or quite three thousand feet above their original level, and still left in a horizontal position. This singular position must have resulted from a yielding of the strata to a force acting more nearly vertical than seems to have been usual in the faults and folds of this portion of the Appalachians, but still acting from the southeast.

Lying horizontally, the beds resist erosion most readily; and it is owing to this fact that the mountain retains such a height, and that the valley between it and the Cumberland is so narrow and shallow.

On the northwest slope of the mountain these same Conglomerate beds are dipping very steeply, from 70° to 85°, or almost vertical. This change in dip is due to a fold or bend in the strata, and not to a fault.

The actual bend in the lowest member of the Conglomerate shown on this mountain was exposed as shown in the section (plate I). This stratum is a coarse pebbly sandstone about 100 feet thick. In a hollow at the head of a small drain, a bend of about 85° in this rock was seen. This was probably very near the axis of the fold, and, in consequence, the rock had not been shattered as much as higher up on the arch of the fold. The section shows how much of the folded rocks has been eroded. It will also be seen that the higher members of the Conglomerate series have been entirely eroded from the top of Brush Mountain. On the slope of the mountain a thickness of 1,350 feet of steeply inclined Conglomerate and inter-conglomerate beds has been measured, and it is probable, from certain slope indications, that there is an additional thickness above this of 200 to 400 feet which is not well exposed, and was not measured.

Of this great thickness of rock only about 700 feet remain on the top of the mountain, where the beds are horizontal.

On the face of Cumberland Mountain a thickness of the Conglomerate series occurs which approximates 2,000 feet. The relation which these beds hold to those on Brush Mountain has not yet been satisfactorily determined. If there be simply another bend or fold along the valley of Martin's Fork, this series must come below the Brush Mountain rocks, and we then would have a total thickness of the Conglomerate series of between three and four thousand feet, a thickness which is greater than is certainly known to occur at any other point. For this reason it seems probable that there is a fault between the two mountains, along the upper Martin's Fork valley, and it has been so indicated in the section. This fault has, in fact, probably determined the course of Martin's Fork.

The section (plate II) of Cumberland Mountain at Crank's Gap, between fifteen and twenty miles further up the moun-

tain, shows a structure somewhat similar to that just discussed, only in this case the fold has not been as great, and, in consequence, erosion has not had so great an effect. The mountain is, therefore, undivided by any valley, and the rocks are still intact at the folds.

The forces of elevation have evidently acted in the same direction, and we have here the two changes in dip—a steep dip on the northwest slope, a much more gentle dip on the main body of the mountain, and a steeper dip again at the crest. The first change in dip, as on Brush Mountain, is due to a fold, while it is also uncertain if the upper change be due to a fold or a fault. If it be a fold, there is here shown a thickness of about 2,600 feet of the Conglomerate series; if a fault, about 2,000 feet. There is, however, very slight evidence of a fault.

Pine Mountain is a simple monoclinal mountain, formed by an uplift along a fault line which has a course of about N. 30° E. The rocks are the same as on the Cumberland Mountain, except that they do not extend as low down.

The highest rocks of the Pine Mountain are those of the Conglomerate series. At the time of its elevation the Carboniferous strata, which originally covered all this region, and which are now found in the Black Mountains, covered the Pine Mountain, which was therefore of far greater height than at present; but as these rocks are comparatively soft and friable, they have been eroded.

The mountain is of comparatively recent elevation, as is proved by the fact that the crest has retreated but a short distance from the fault line. At some few places, one of which happens to be where the section line (plate I) crosses, the retreat of the crest has been as much as a half mile; but at many other places it is only a few hundred feet. Undisturbed horizontal coal measures are found to the northwest of the fault line, and but a few hundred feet from it.

The amount of uplift along this fault has not yet been accurately determined, for the reason that the exact geological position of the horizontal coal measures on the opposite side

of the fault line is not known. The uplift is certainly over three thousand feet, for that thickness of strata is found on Pine Mountain at the point crossed by the section (plate I). It was impossible here, as generally on Pine Mountain, to obtain a complete section, as the lower rocks are mostly covered by a great thickness of talus from those above.

The Conglomerate series here is two thousand feet thick. It is not as well exposed as on Cumberland Mountain. The lower rocks, the Sub-carboniferous limestone, the Waverly, and the Devonian, &c., are so imperfectly exposed that no reliable estimates of their thickness can be given.

The Black Mountains are irregular ridges and peaks, presenting the familiar topographical features which are formed by the action of water upon horizontal strata.

They are the continuation of the Log Mountains to the northeast, and the geological equivalents of the "Cumberland table-land" of Tennessee.

They frequently reach a height above the valley of about two thousand feet, equivalent to 3,400 to 3,500 feet above tide.

The character of their rock structure will be seen from the sections (plates I and III). The prevailing type of rock is shaly or thin-bedded sandstone. These are diversified by occasional harder, massive sandstones, which are more common toward the upper part of the sections. Limestones, except as occasional calcareous concretions, are not found. The thickness of coal measures in this valley is greater than in any other part of Kentucky by many hundred feet. The number of coals is also greater, and they differ widely in position from any other region. Sufficient work has not been done to enable us to give a general section which will serve as a key to the stratification of this whole valley; but a single comparison of the general section for Greenup, Carter, and Boyd counties, by Mr. Crandall, the only one heretofore constructed for any portion of Eastern Kentucky, with the sections of this report, will show the great difference in the structure of this region. It shows also the impossibility of making a general section which will hold over a large area.

The section in the Black Mountains (plate I) shows 11 different coals. The section of Gray's Peak (plate III) shows 9 coals. Neither of these sections are by any means complete. It is probable that, on more thorough examination, several other coal beds will be discovered. A section of one of the Log Mountains, made in 1875 by Mr. Crandall, showed no less than 17 different coals. It will be seen from the sections of plate III that the covered spaces, where the rocks were not exposed, aggregate from one third to one half the whole thickness. There is, therefore, every reason to suppose that other coals will be found occupying some of these spaces. There is the more reason for this in the fact that this region is almost entirely undeveloped. There has been no search for coal; and in making sections, reliance has been placed entirely upon natural exposures. The coals vary in thickness from a few inches to five feet. The most common thickness, so far as seen, is about two feet; but workable seams of three feet and upwards are known at four or five different levels.

The quality of the coals of this valley is most excellent. The proportion of ash and sulphur is very low in all that have yet been analyzed, with the exception of one cannel coal, and the fixed carbon is high.

The following analyses, by Dr. Peter and Mr. Talbutt, of two samples from the vicinity of Mt. Pleasant, Harlan county, show the excellent quality just referred to:

	No. 1.	No. 2.
Moisture	1.70	5.20
Volatile combustible matter	35.70	31.26
Fixed carbon	59.60	60.08
Ash	3.00	3.46
Total	100.00	100.00
Coke	62.60	65.54
Sulphur	0.750	0.618
Specific gravity	1 289	1.356

No. 1 is from Howard's bank, Clover Fork.

No. 2 is from Skidmore's bank, Martin's Fork.

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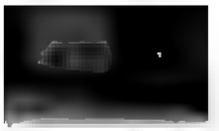

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